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FRANKLIN INSTITUTE,

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SCIENCE AND THE MECHANIC ARTS.

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VOL. CLXIV, No. 1 82ND YEAR JULY, 1907

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Mining and Metallurgical Section.

(Stated Meeting held Thursday, May 9th, 1907.)

Extract of Report on the Methods Used to Avoid Piping in Steel Ingots, as Applied in the Hungarian Government Steel Foundries at Diosgyör.

BY ENGINEER ALBERT OBHOLZER.

(READ BY TITLE.)

The modern development of the machinery of rolling mills has brought about with it higher requirements in regard to the quality of the raw material.

Various means have been employed to remove the so-called "piping" in ingots, by various shapes of ingot molds or by placing the ingot under pressure before the steel has set. The most successful of these methods has been that invented by Mr. Harmet, Director of the steel works in San Etienne, which, however, requires rather elaborate machinery.

A method proceeding on entirely different lines is the Anti-Piping Thermit method, which has shown, in our practice, considerable advantages over the Harmet process.

A number of experiments were made at the Diosgyör works, in the casting of Martin Steel ingots. For the purpose of comparison, two blocks were poured out of the same charge—one with, and the other without an addition of Anti-Piping Thermit. These ingots were then cut longitudinally with a saw, up to a one-third of their axis, and the middle of the ingot was then cracked by means of wedges.

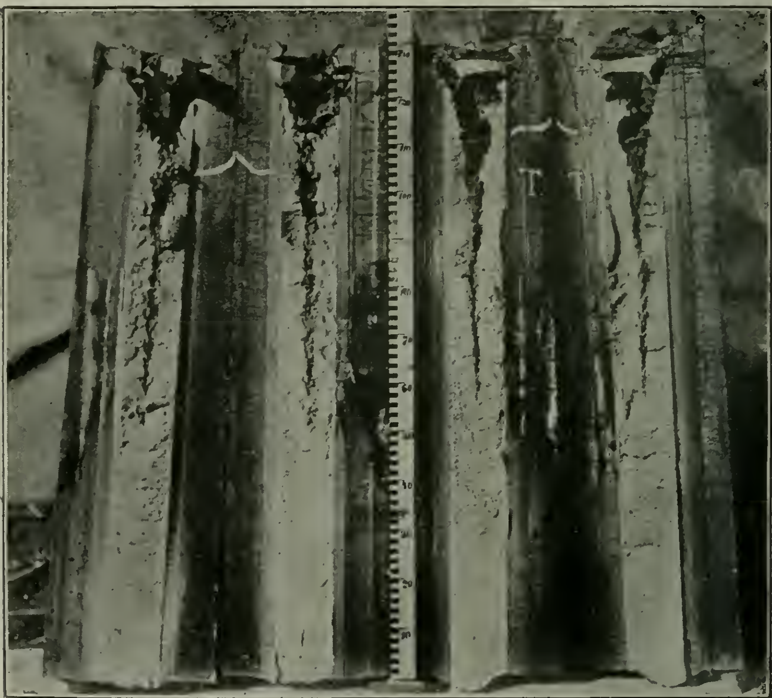

Fig. 1.

The blocks marked "T" on the accompanying cut, are those cast with the addition of Anti-Piping Thermit.

For the purpose of these tests, the usual practice of making a second pour a little after the first, was not followed, either in the ingots with or without Anti-Piping Thermit. Figures 1 and 2 show the ingots poured in this manner, cut on both sides and broken in the middle.

Cut No. 1 shows ingots cast in the so-called "Goliath" block

molds, without feeding heads, and those in cut 2, cast in octangular molds, with feeding head. The feeding head consisted of refractory brick walls, which were heated to a red heat.

It will be observed that the piping in the ingots treated with Anti-Piping Thermit is not so extensive and does not reach down so far as in those without Thermit. The exact measurements are as follows:

FIGURE I, WITHOUT THERMIT.

Piping visible to the naked eye	808 m.m.	in length.
" " with the microscope	34 "	"
Total	842 m.m.	

INGOT TREATED WITH THERMIT.
Marked "T. T."

Piping visible to the naked eye	760 m.m.
" " with the microscope	20 "
Total	780 m.m.

PIPING IN INGOTS, FIGURE 2.
POURED INTO OCTANGULAR MOLDS WITH FEEDING HEAD.
INGOTS WITHOUT THERMIT.

Piping visible to the naked eye	1060 m.m.
" " with the microscope	10 "
Total	1070 m.m.

INGOTS CAST WITH THERMIT, SAME CONDITIONS.

Piping visible to the naked eye	930 m.m.
" " with the microscope	75 "
Total	1005 m.m.

Figures 3 and 4 represent ingots cast according to regular practice, with feeding head, which, after the pour, are kept hot by being covered with charcoal or other material.

In casting ingot shown in Fig. 3, $5\frac{1}{2}$ lbs. of Thermit were applied and the piping in the upper part of the ingot is practically nil. The ingot shows a homogenous grain in its entire fracture.

Figure 4 represents octangular blocks cast without Anti-Piping Thermit, with feeding head as described above.

The fracture of the heavier ingot—four tons—is without flaw, except the piping in the upper part of the head. (See explanation below.) This piping extends from the upper part of the ingot 300 m.m.; from the lowest point of contraction, 140 m.m.

The fracture of the ingot weighing two tons is perfect in every respect.

The advantage of pouring such ingots with feeding heads is therefore very apparent. The *modus operandi* is as follows:

In order to keep the steel liquid in the feeding head, the latter is surrounded by brick walls and well banked up with sand, and is heated, so as to prevent the ingot from radiating its heat. Anti-Piping, during its reaction, develops an enormous

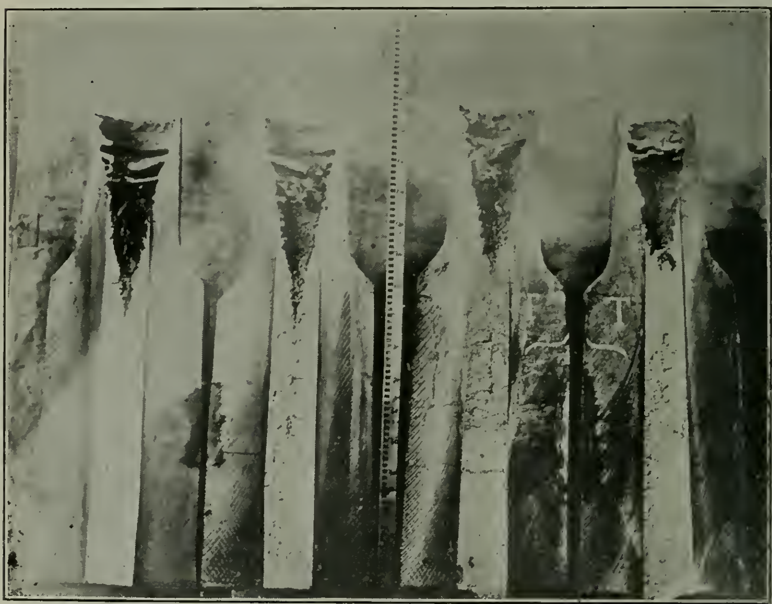

Fig. 2.

temperature, and in so doing, renders the contents of the feeding head, which was at the point of chilling, fluid again. It will then fill up the hollow spaces that have formed in the interior of the steel and the pouring of fresh fluid steel into the mold can continue until the piping is entirely removed.

The Anti-Piping Can is attached to an iron bar with a cross bar, to simplify the handling, and is then pushed into the mold. The can must be so fastened by either wire or wedge that it cannot slip up on the rod.

When the steel has been poured into the mold, the can is

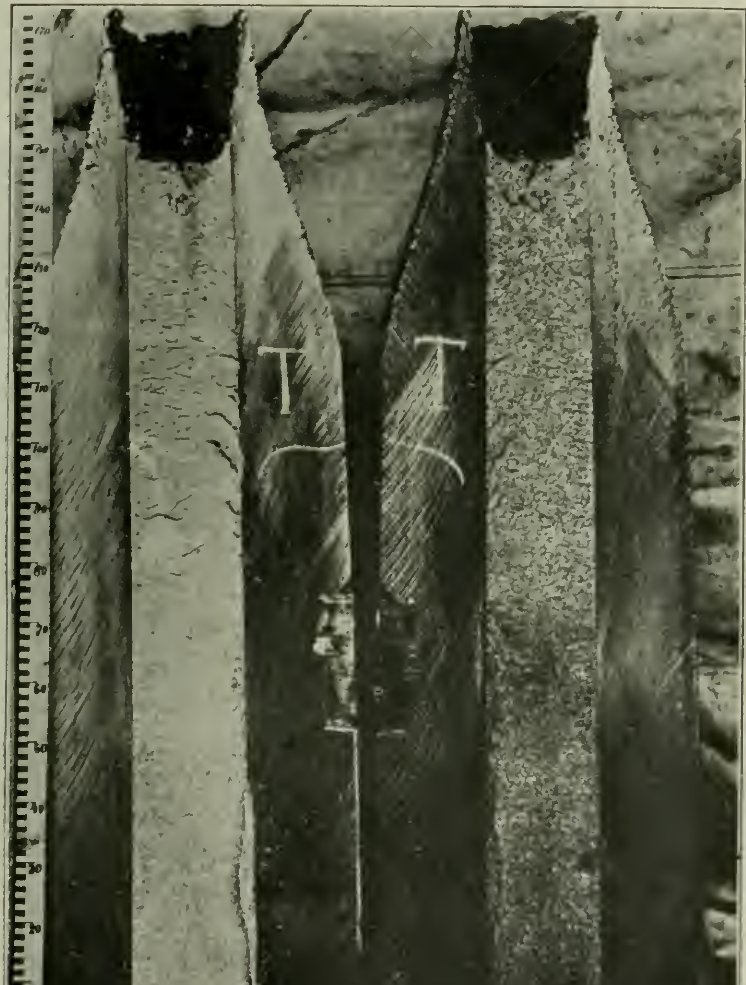

Fig. 3.

pushed into the interior to a depth of about three inches or more, according to the size and weight of the ingot. The reaction of the Thermit starts at once and is over in from five to ten seconds. A violent ebulition of the steel takes place, and the slag separated by the Anti-Piping Thermit rises to the surface. This slag must be removed with an iron bar and more fluid steel must be then added out of the ladle.

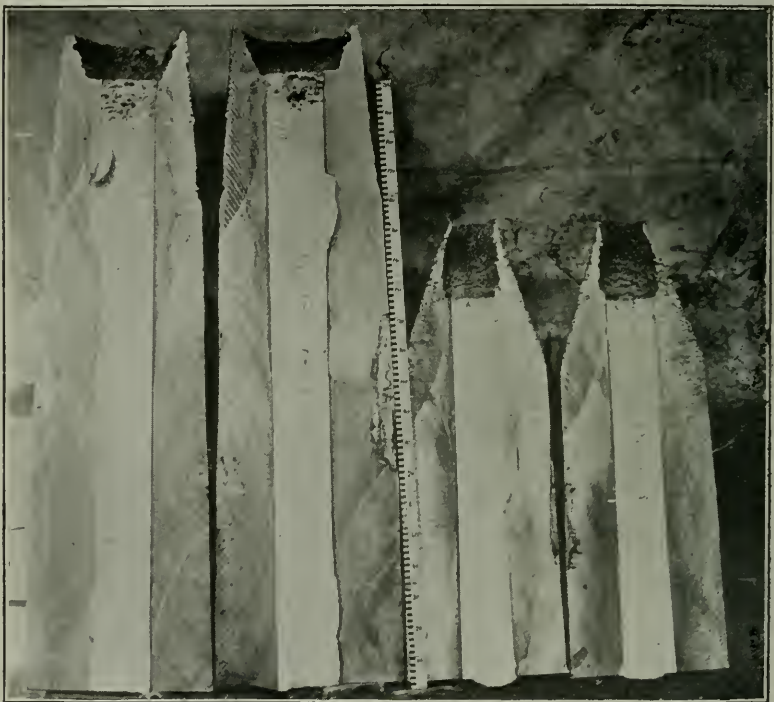

Fig. 4.

The Anti-Piping Thermit is supplied in various sized cans, according to the weight of the ingot.

Diosgyör Works used the Anti-Piping Thermit for such blocks from which complete pieces are rolled or forged, and have then ingots quite free from piping, or, in case of wrought iron blocks, only a small part has to be cut off.

The saving in material completely overbalances the cost of the application of the Anti-Piping Thermit and the actual cost

prices are not increased. Even should some of the blocks cast with feeding head but without Anti-Piping Thermit be not very much inferior to those cast with the Thermit, nevertheless the application of Thermit is considered a safer way than the other methods and the Diosgyör Works are convinced that the use of the Thermit is most advantageous. The clearest proof is the fact illustrated in Figures 1 and 2, where ingots poured with Thermit are of superior quality, even though no additional steel was poured in afterwards; in other words, the ingot showed a smaller extent of piping than those cast without Thermit.

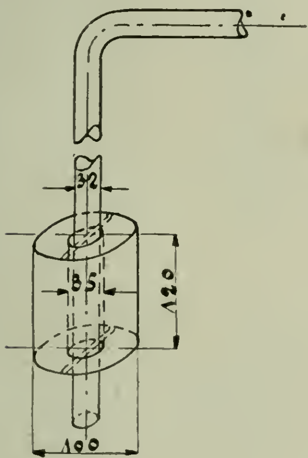

Fig. 5.

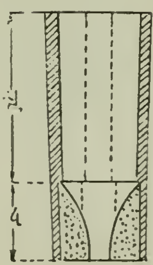

Fig. 6.

In the construction of the ingot mold, and particularly the feeding head, the essential point to be aimed at is to protect the liquid steel against loss of temperature. It should be kept liquid until the piping can be completely filled up from the feeding head.

A comparatively large mold must be provided for the feeding head, allowing for a sufficiency of material to fill up the piping. On the other hand, an unnecessarily large feeding head will simply mean waste steel and an unnecessary increase in the cost of manufacture, and is therefore to be avoided.

The mold represented in Figure 6, which was used for pouring the ingots shown in Figure 4, answers these conditions.

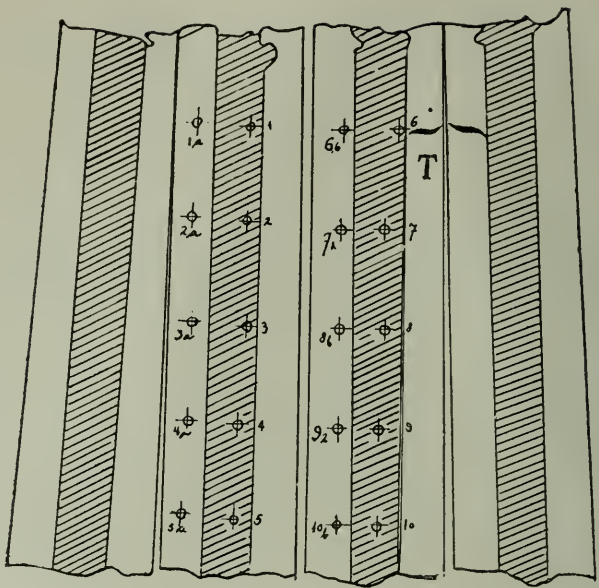
1a
1
2a
2
3a
3
4a
4
5a
5
6b
6
7b
7
8b
8
9b
9
10b
10
T

Fig 7

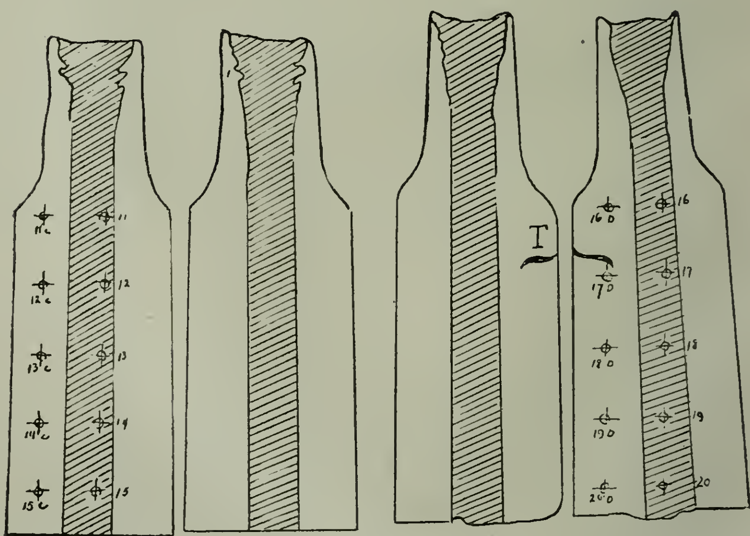
11c
11
12c
12
13c
13
14c
14
15c
15
T
16D
16
17D
17
18D
18
19D
19
20D
20

Fig. 8.

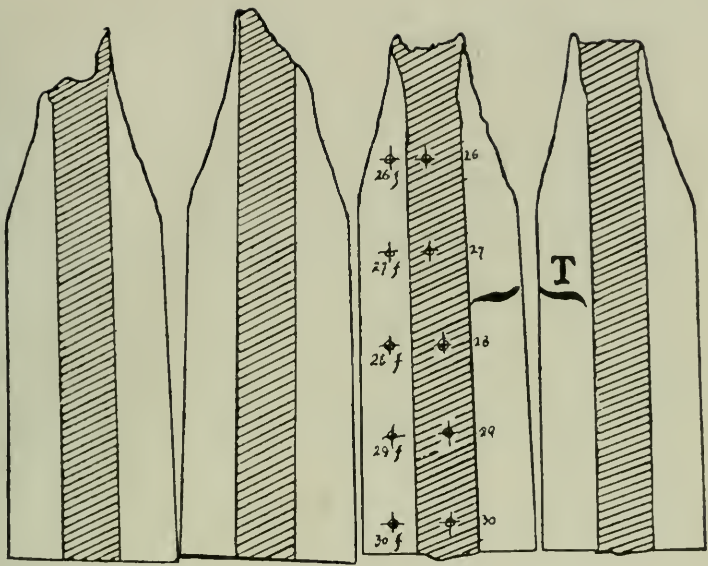
26 f
26
27 f
27
T
28 f
28
29 f
29
30 f
30

Fig. 9.

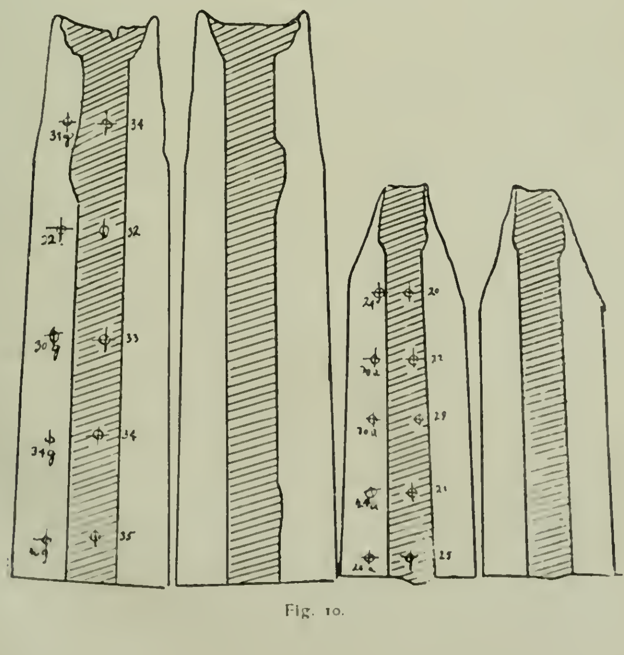
31 g
34
32
30 g
33
34 g
34
35
20
22
28
21
25

Fig. 10.

For ascertaining the height of the feeding head, the following empiric formula has been found practicable:

$$h = \frac{H}{2.4}$$

"h" is the head and "H" means the height of that part of the ingot free from piping which can be used.

The round opening at the top part of the mold, rammed with sand, should have a diameter of eight to twelve inches, according to the size of the ingot. A larger opening is inadvisable, as a considerable amount of heat would be lost by radiation. Even with the most careful handling of the head, the piping would form in the upper part of the block and could not then be filled by the material in the feeding head, on account of the latter having chilled. This danger is avoided by the narrow opening.

The four-ton block (Fig. 4) is a case in point.

The considerable amount of piping found in the square ingots of Figure 1, is due to the upper part of the ingot having been left open in its entire section and offering a large surface for radiation; besides this, the mistake had been made not to surround the mold with a bad conductor of heat. The liquid steel meeting with a good conductor of heat, such as the cold walls of the ingot mold, gives off its temperature to the latter too rapidly. It congeals and forms a coating in the mold, to which the liquid material in the interior gradually adds as congelation proceeds. The piping does not appear at the bottom, on account of the weight of the partly fluid material in the upper half, which latter cannot be filled owing to the absence of the feeding head. It is a matter of general observation that where the steel congeals slowly, some of the components, as "C," "Si," "Mn," "P," "S" and "Sb," segregate toward the longitudinal axis of the ingot and toward its upper part. In the direction of the longitudinal axis in the interior there is always a greater proportion of impurities than in the outer parts. The segregation is more marked the greater the time consumed in cooling. In using the Thermit reaction, this cooling is delayed and the material is kept liquid for a longer space of time. Therefore, the segregation must be greater in ingots treated with Anti-Piping Thermit than in those without.

ANALYSIS OF THE BORINGS TAKEN FROM THE BLOCKS.

DESIGNATION OF THE BORINGS.

RESULTS OF THE ANALYSIS IN %.

	Near the Longitudinal Axis.					*Near the Outside.*					
	1.	2.	3.	4.	5.	1a.	2a.	3a.	4a.	5a.	BLOCKS
C	0.231	0.172	0.173	0.174	0.172	0.164	0.194	0.204	0.194	0.201	CAST.
Si	0.191	0.172	0.168	0.168	0.168	0.186	0.186	0.186	0.186	0.186	Without
Mn	1.108	1.089	1.079	1.060	1.060	1.108	1.108	1.123	1.127	1.108	Thermit
Cu	0.127	0.127	0.111	0.119	0.111	0.111	0.111	0.096	0.111	0.111	
P	0.031	0.010	0.011	0.024	0.006	0.022	0.024	0.024	0.026	0.025	Fig. 1
S	0.055	0.070	0.080	0.050	0.040	0.070	0.050	0.055	0.055	0.040	
	6.	7.	8.	9.	10.	6b.	7b.	8b.	9b.	10b.	
C	0.231	0.163	0.172	0.182	0.154	0.172	0.184	0.184	0.183	0.192	
Si	0.191	0.172	0.191	0.196	0.191	0.186	0.186	0.196	0.168	0.168	With
Mn	1.089	1.038	1.038	1.060	1.026	1.089	1.127	1.108	1.127	1.108	Thermit
Cu	0.127	0.127	0.119	0.127	0.127	0.093	0.096	0.096	0.098	0.096	
P	0.026	0.020	0.013	0.024	0.008	0.019	0.025	0.019	0.024	0.023	Fig. 1
S	0.045	0.060	0.065	0.040	0.065	0.060	0.050	0.050	0.050	0.050	
	11.	12.	13.	14	15	11c.	12c.	13c.	14c.	15c.	
C	0.250	0.192	0.192	0.192	0.201	0.192	0.172	0.175	0.175	0.172	
Si	0.154	0.163	0.186	0.158	0.154	0.186	0.177	0.177	0.168	0.168	Without
Mn	1.098	1.079	1.108	1.050	1.108	1.169	1.108	1.159	1.127	1.108	Thermit
Cu	0.127	0.119	0.119	0.119	0.119	0.093	0.096	0.104	0.111	0.119	
P	0.030	0.024	0.019	0.009	0.008	0.028	0.022	0.023	0.021	0.019	Fig. 2
S	0.080	0.050	0.050	0.055	0.065	0.070	0.060	0.055	0.050	0.060	
	16.	17.	18.	19.	20.	16d.	17d.	18d.	19d.	20d.	
C	0.250	0.182	0.162	0.202	0.174	0.212	0.190	0.173	0.172	0.172	
Si	0.154	0.168	0.186	0.182	0.186	0.168	0.158	0.168	0.154	0.196	With
Mn	1.200	1.070	1.026	1.073	1.050	1.127	1.089	1.108	1.108	1.089	Thermit
Cu	0.111	0.104	0.119	0.088	0.096	0.111	0.104	0.104	0.096	0.085	
P	0.028	0.024	0.023	0.005	0.005	0.027	0.023	0.025	0.020	0.024	Fig. 2
S	0.100	0.080	0.050	0.030	0.025	0.060	0.080	0.060	0.075	0.070	
	26.	27.	28.	29.	30.	26f.	27f.	28f.	29f.	30f.	
C	0.409	0.290	0.251	0.231	0.251	0.283	0.223	0.242	0.223	0.223	
Si	0.187	0.159	0.181	0.163	0.177	0.150	0.191	0.177	0.177	0.177	With
Mn	1.171	1.118	1.036	1.026	1.060	1.159	1.169	1.169	1.159	1.127	Thermit
Cu	0.104	0.096	0.096	0.079	0.079	0.096	0.096	0.079	0.079	0.072	
P	0.029	0.019	0.016	0.016	0.018	0.019	0.023	0.018	0.020	0.014	Fig. 3
S	0.050	0.035	0.040	0.030	0.030	0.025	0.030	0.040	0.040	0.015	
	31.	32.	33.	34.	35.	31g.	32g.	33g.	34g.	35g.	
C	0.329	0.241	0.192	0.192	0.211	0.344	0.234	0.223	0.184	0.194	
Si	0.144	0.140	0.140	0.150	0.140	0.177	0.150	0.177	0.168	0.168	Without
Mn	0.983	0.887	0.858	0.887	0.922	0.956	0.956	0.925	0.915	0.915	Thermit
Cu	0.079	0.072	0.072	0.072	0.072	0.072	0.067	0.072	0.072	0.072	
P	0.020	0.019	0.014	0.014	0.015	0.015	0.006	0.019	0.006	0.014	Fig. 4
S	0.030	0.025	0.030	0.020	0.030	0.015	0.015	0.020	0.015	0.015	
	21.	22.	23.	24.	25.	21c.	22c.	23c.	24c.	25c.	
C	0.525	0.481	0.524	0.484	0.484	0.438	0.492	0.492	0.472	0.458	
Si	0.196	0.191	0.214	0.205	0.210	0.196	0.205	0.186	0.196	0.196	With
Mn	1.089	1.073	1.050	1.054	1.025	1.089	1.089	1.089	1.089	1.089	Thermit
Cu	0.096	0.096	0.096	0.085	0.079	0.079	0.079	0.088	0.080	0.085	
P	0.033	0.018	0.031	0.027	0.027	0.023	0.025	0.030	0.025	0.027	Fig. 4
S	0.020	0.015	0.035	0.015	0.020	0.020	0.015	0.020	0.015	0.015	

In order to obtain confirmation of this, holes were drilled into the fracture of the ingots, in the direction of the longitudinal axis, as well as in the outer parts, taking the borings for the purpose of analysis. The accompanying table will show the results obtained. The thousandths parts have been left out. Following are the observations made in connection with these analyses:

First—On using a mold without feeding head, the steel congeals comparatively quickly and the effect produced by Anti-Piping Thermit cannot be so great as in those cast with a feeding head. There is, therefore, no great difference in the segregation.

Second—In ingots provided with feeding heads, in which the steel in the interior of the upper half of the ingot remains liquid for a comparatively longer space of time, the segregation of various elements and their situation in the respective parts of the ingot, due to specific weight, is more distinct. Naturally, in ingots cast with Thermit, the segregation reaches a greater extent.

In Figure 8 (analysis 11-20), cast with Thermit, a considerable increase in the contents of "C," "Mn," and "S" is observed in the upper part.

In the analysis obtained from Figures 9 and 10 (analysis 21-31), the rapid increase of "C" is striking. This may be explained by the fact that the ingots were cast without Thermit and the head covered with charcoal, from which the liquid steel absorbed a quantity of carbon, which in its turn was carried into the interior of the ingot by the material running from the feeding head into the piping.

THE FRANK THOMSON RAILROAD SCHOLARSHIPS.

At a meeting of the Board of Directors of the Pennsylvania Railroad Company, March 27, the offer of Anne Thomson, Frank Graham Thomson and Clark Thomson of a fund of $120,000 to establish what are to be known as the "Frank Thomson scholarships" was accepted and approved. The purpose is to afford to "sons of living or deceased employees of all the lines of the railroad an opportunity for a technical education, so as to better enable them to qualify themselves for employment by the company." Competitive examinations are to be held, open only to sons of Pennsylvania employees, "corresponding in general to the entrance requirements of the scientific departments of the higher class universities, colleges and technical schools." After passing the examinations held by the company the winner of a scholarship must qualify for admission to one of the technical schools or departments approved by the company before he receives his certificate entitling him to draw upon the scholarship fund. Beginning this year two scholarships, each of which amounts to $600 a year, are to be filled, and every year two will be added. After four years two will be graduated annually, keeping a total of eight men in college all the time.

HOW SCIENCE IS HANDICAPPED.

A paragraph of undoubted economic interest is the following, which was written by Mr. S. F. Emmons in summarizing for the forthcoming "Economic Bulletin," the work of the United States Geological Survey, during 1906, in the investigation of metalliferous ores:

"The increasing exodus of members of the economic force of the Survey in consequence of their employment by large mining organizations at salaries much greater than those they have been receiving from the Government, seriously impairs the efficiency of the work of this branch of the Survey. It is only by years of practical experience in the field that the geologist, however excellent his preliminary training, becomes competent to carry on independent work in investigating a mining district, and the loss of trained men in this work is, for a time, irreparable."

Rifling steel pipe for reducing friction in oil lines was described in a paper read before the Engineers' Society of Western Pennsylvania by F. N. Speller of the National Tube Company, who referred to the fact that in the California field a quantity of steel pipe has been rifled, the object being to cause the viscous oil intermixed with a small percentage of water to whirl as it moves rapidly through the pipe. Thus, when a sufficient velocity is attained, a layer of water flows between the oil and the pipe, reducing the friction in the line. It has been found quite practicable to roll spiral corrugations $\frac{3}{32}$ in. deep in the surface of the pipe by means of six wheels set equidistant around the circumference and slightly inclined to the axis of the pipe, so as to make a complete revolution on the surface of the pipe every ten feet. The material seems to stand this treatment cold without difficulty.—*Metal Worker, Plumber and Steam Fitter.*

(Stated Meeting held Thursday, January 26th, 1906.)

The Schuyler Mine.

By J. H. Granbery,

Associate Member Am. So. C. E., Member of the Institute.

Vast sums are invested in the mining and reduction of copper ore in the United States, but only recently has this industry been brought to its present stage of development; it seems, therefore, that a more than passing interest may attach to the early history of what was at one time not only the only copper mine, but, indeed, the first mine of any kind operated by Europeans within the limits of the original thirteen States. Much of the mechanical development of the present day is to be traced directly to the far-sighted men who brought to, and installed in, this country the first steam-driven machinery; the first mine and the first steam engine are indissolubly associated with the engineering, as they were formerly with the political, development of our country.

The Schuyler Mine (which this account considers) is located upon property, secured by Captain William Sanford of the British Army, under the terms of an agreement made with William Kingsland. The present town of Kingsland, New Jersey, was named from the old proprietors, and situated upon a part of the estate. Kingsland is said to have been a kinsman of Oliver Cromwell. The patent of Captain Sanford was issued July 4, 1668, "in lieu of the payment of twenty pounds Sterling per annum, forever," as well as on the payment to natives of several hundred strings of wampum, knives, brandy, etc.; this patent conveyed approximately 10,000 acres of meadowland and 20,000 acres of upland, lying between the Hackensack and Passaic rivers, and from their intersection to a point seven miles above; it was known in those days as the "New Barbadoes." Shortly after its acquirement by Sanford,

he transferred to Kingsland the upper portion of this tract. In the year 1710, Arent Schuyler purchased from Kingsland a large tract of land comprising the lower portion of Kingsland's property; upon this tract the mine was located and the Schuyler's home was erected (but afterwards destroyed by fire); and along the eastern bank of the Passaic, opposite the present town of Belleville, stands to-day another old frame mansion, pointed out as the home of the Schuylers', more than a century ago.

Arent Schuyler was born at Albany, N. Y., in 1662, and was the sixth son of Philip Pieterse (Van?) Schuyler (who came from Holland a few years before and was one of the two founders of the family in America.)

In the eastern portion of the upland, at what is even now known as Schuyler's Corner, stood the house of Arent Schuyler; on the meadow land below the hillside, between it and the dense cedar swamp, lay the fertile soil that he cultivated as a part of his plantation. Here, in 1714 or 1715, a discovery was made by a negro slave who, while ploughing, turned up a large stone, the weight of which so excited his curiosity that he carried it to his master. Upon Schuyler's learning that it came from a bed of rock of the same character, he sent it to England for analysis; he learned that it contained nearly eighty per cent. of copper.

The old tradition runs to the effect that Schuyler, wishing to reward the virtual discoverer of the mine, gave him his freedom, and told him to make three wishes, which would be granted in addition. The first wish was to live with his master as long as he lived, and to have a dressing gown "with big brass buttons, just like massa's." The second wish was for all the tobacco he could use; the negro was at a loss to name the third. He was urged to ask for something valuable; after studying for some time and scratching his head, he said, "I guess, massa, I'll hab a little more 'baccy."

The scanty literature of those days makes mention of the mine; it was evidently of considerable importance, for Brig. Gen. Robert Hunter (Governor of the Colonies of New York and New Jersey), writing from New York, November 12, 1715, to the Lords of Trade, states regarding it: "There being a Copper Mine here brought to perfection, as you may find by

the Custom House books at Bristol, where there was imported from this place about a Tonn in the month of July or August last, of which copper farthings may be coined." etc.[1]

Also, the records tell us that "in April 1721, there were 110 casks of ore from this mine shipped from New York to Holland, and the Surveyor of the Port of N. Y., wrote that 'Copper Oare now rises very rich and in great plenty in a new-discovered mine of one Mr. Schuyler in New Jersey.'"[2] The shipment of the ore to Holland excited the apprehensions of the Lords of Trade, who suggested that it should be prevented by act of Parliament. At the request of the Duke of Newcastle, one of the Lord Justices of the Treasury, Governor Montgomerie conferred with Col. Schuyler, in relation to the matter, but could only secure from him the promise that the English Copper Co. should have the first sight of his ore when his ships arrived in England with it.[3] This was in 1730. Curiously enough, the New Jersey Legislature came to the relief of the English manufacturers, in 1734, by imposing a duty of 40 shillings per ton on all copper exported from the province not directly to Great Britain; and still more strangely, the first complaint against this measure came from Bristol, England, where were extensive brass and copper factories. It was found in practice that the law was evaded by shipping the ore to New York and thence to England or other countries; but the Bristol traders feared the act would discourage mining operations in the province.[4]

For many years the mine yielded large quantities of rich ore, until it was worked as deep as hand and horse power could clear it of water; of this period we learn much from the following extract from a book of that time:

"Schuyler's Copper Ore is from a Mine in Jersies, but exported from *New York*, therefore it is mentioned in this Section. In the beginning of this Discovery it seemed to be very rich; it appears that it was formerly wrought by the *Dutch*, because in new working of it, were found Hammers, Wedges, &c. it sold in Bristol the Ore at £40 ster. per Tun. The Cartage to *Hudson's* River is short, and their first Agreement with

[1] Thos. F. Gordon Gazetteer of N. J., Trenton, 1834.

[2] New Jersey Archives V, p. 7.

[3] New Jersey Archives V, pp. 7, 9, 267.

[4] New Jersey Archives V, pp. 376-406.

the Miner, was to allow him one-third of the Ore for raising and laying it above Ground; it was done up in quarter Barrels, whereof six made a Tun. The richness of this Copper Mine made so much Noise in the World, that a few Years since, to engross this Ore for the benefit of *Great Britain*, it was by Act of Parliament enumerated; but lately it has not been Wrought and Exported, as appears by the quarterly Accounts of the Custom-House of *New York*; I cannot account for this."[5]

In the meantime Arent Schuyler had died; his will was proven July 6, 1732,the mine being left to his three sons. Col. John Schuyler, one of his sons by his second wife, had the management of the mine for himself and his brothers.

"Benjamin Franklin visited the mine in 1749, and on February 13, 1750 N. S. (New Style) he writes to Jared Eliot from Philadelphia:[6] 'I know of but one valuable copper mine in the country, which is that of Schuyler's in the Jerseys. This yields good copper and has turned out vast wealth to the owners. I was at it last fall, but they were not then at work. The water has grown too hard for them, and they waited for a fire-engine from England to drain their pits; I suppose they will have that at work next; it costs them one thousand pounds sterling.' "

That Dr. Douglass could not account for the non-working of the mine is not strange when we consider the difficulty of communication; indeed, the engine, ordered in 1748 or 1749, was not shipped from England until four years had passed.

Steam engines (or more truly speaking, atmospheric engines, for all of that date were of the Newcomen type) were then being used with great success in the coal mines of that part of England known as the "Black Country," and in the deep tin and copper mines of Cornwall.

Joseph Hornblower and his sons were engaged in the construction of "fire engines," as they were called at that time, and it was to him that Col. John Schuyler sent for the machine which was to play so important a part in the development of

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[5]"A Summary, Historical and Political, Of the first Planting, progressive Improvements, and present State of the *British* Settlements in NORTH AMERICA. By William Douglass, M. D., Vol. 2. Boston, New England; Printed and Sold by D. Fowle in *Ann Street* facing the Town Dock, 1753." pages 257, 258.

[6]Works of Franklin, edited by Jared Sparks, Boston, 1838. V 1, p. 107.

mechanics in this country. Col. Schuyler also asked that an experienced engineer should accompany it and set it in position. Josiah Hornblower, then only twenty-four years of age (for he was born in Staffordshire, England, on February 23, 1729), built this engine in England and left home May 8th, 1753, embarking on the sailing ship *Irene*. The engine arrived at New York, September 9, 1753; it was landed at Second River (now Belleville, N. J.), and was carted thence to the Schuyler mine, where Hornblower set it up. In account books of the Schuyler mine, we find this item:

"1753
Sept. 25—To cash pd for 8 days, carting ye engine
& boards to ye mine at 6 s - £2, - 8 ."

The shaft to which the engine was taken was that now known as the Victoria; the engine house was built about 300 feet northwest of the shaft, and the machinery was installed by Hornblower. It was sufficient to keep the flow of water down for many years.

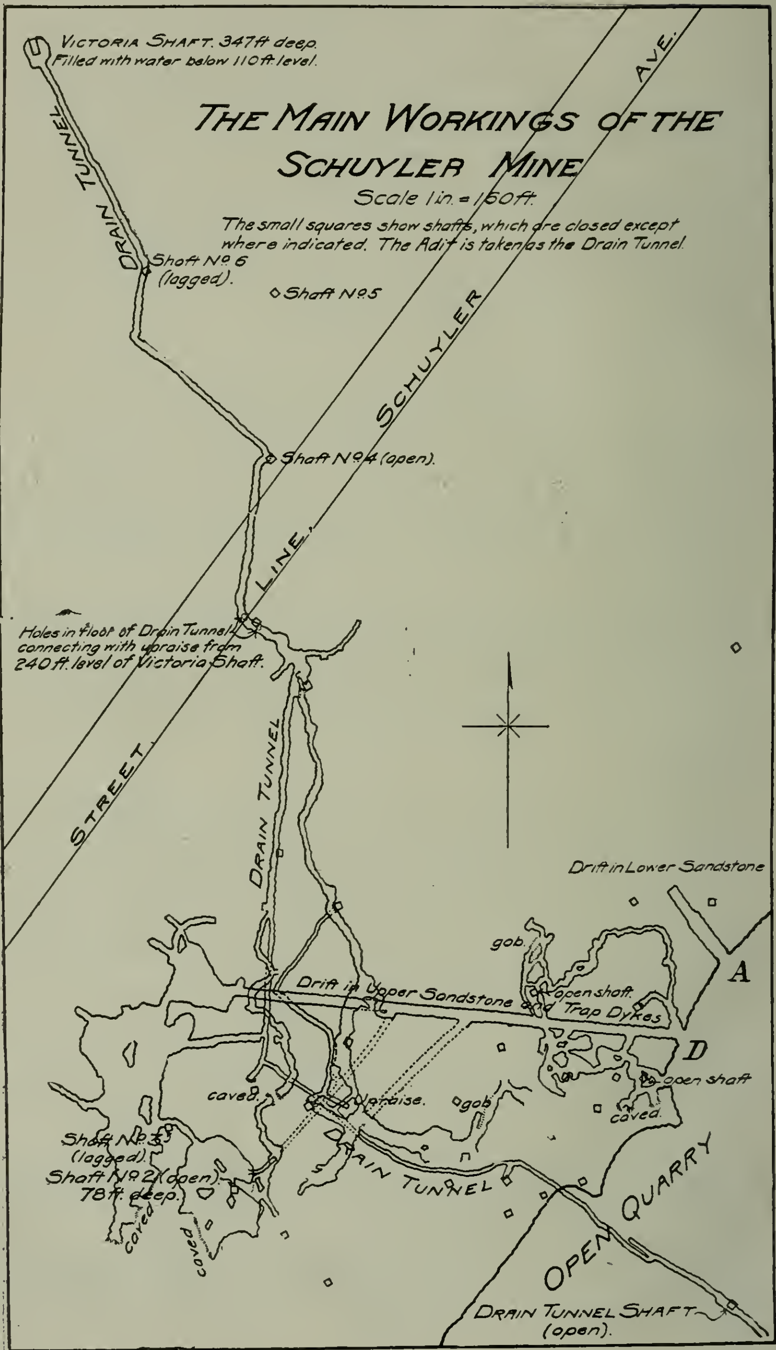
When first brought over there were no facilities for engineering work in the colonies; and the pipe, as well as large numbers of duplicate pieces, was brought with it. Some of the old pipe has been raised; it illustrates the radical difference between the practice of the older day and that of our more modern times.

The pipe was of cast-iron, made in lengths of about eight feet; each individual length had a pair of trunnions cast upon it by which means it was kept in a vertical position while being lowered into place. Some of the pieces of the original pipe brought from England bear the weight mark; thus: "1 2 40," meaning, not 1240 lb., but one ton, two hundred weight, and forty pounds (2504 lb., as it would be marked to-day).

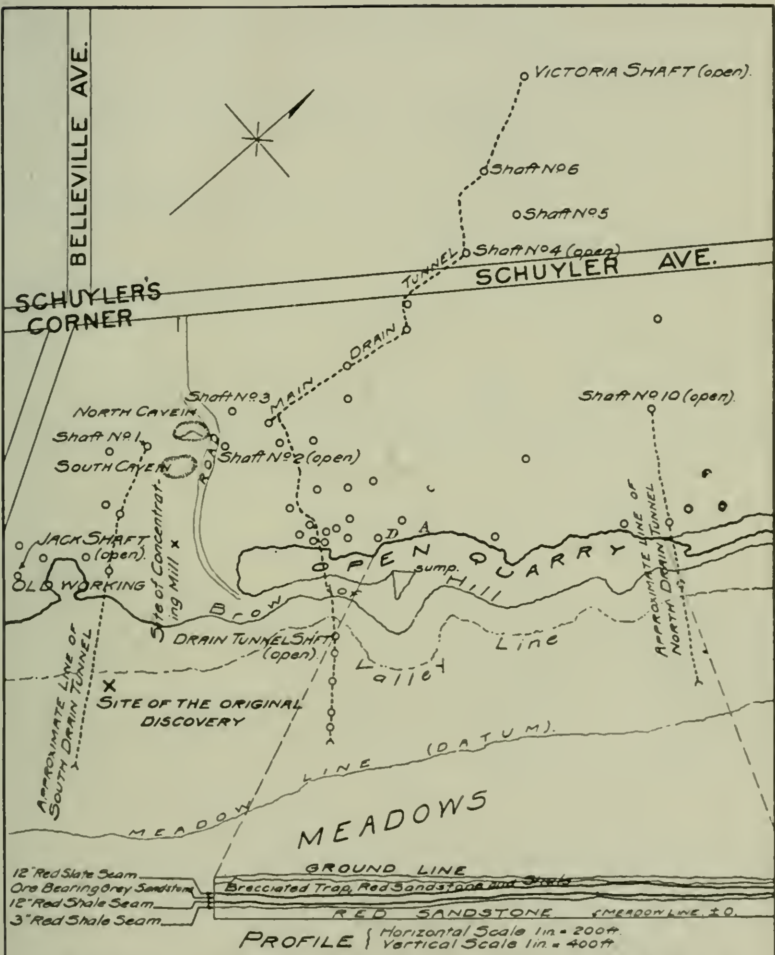
The boiler was either eight or ten feet in diameter and of about the same height; it was placed directly beneath the cylinder, and was connected to it by a short pipe fitted with the valve by which the admission of steam was regulated.

The cylinder was three feet in diameter and eight feet long, and the stroke about six or seven feet, the piston making about ten or twelve strokes per minute.

The safety valve was simply a heavy lid, resting on an opening into the boiler; the valve movement was of the simplest de-



THE MAIN WORKINGS OF THE SCHUYLER MINE
Scale 1 in. = 150 ft.
The small squares show shafts, which are closed except where indicated. The Adit is taken as the Drain Tunnel.
VICTORIA SHAFT. 347 ft deep. Filled with water below 110 ft. level.
DRAIN TUNNEL
Shaft No. 6 (lagged).
Shaft No. 5
Shaft No. 4 (open).
SCHUYLER AVE.
STREET LINE.
Holes in floor of Drain Tunnel connecting with upraise from 240 ft. level of Victoria Shaft.
Drift in Lower Sandstone
gob.
A
Drift in Upper Sandstone and Trap Dykes
open shaft.
D
open shaft
caved.
Upraise.
gob
Shaft No. 3 (lagged).
Shaft No. 2 (open). 78 ft. deep.
caved
OPEN QUARRY
DRAIN TUNNEL SHAFT (open).



GENERAL PLAN OF THE SCHUYLER MINE

Scale 1in. = 400ft.

The small circles indicate old shafts.

scription—a narrow board connected to the walking beam, and holding pins for adjusting the point of cut-off.

Small tanks, holding water for condensing the steam, were supported on a frame several feet higher than the cylinder; the condensed steam drained into a hotwell alongside the furnace. The space above the piston was open to the atmosphere, and the pressure on it was just a little more than necessary to lift the water from the required depth.

The pump cylinder was ten inches inside diameter; the pump rod was six inches square, the original pipe being about six inches diameter.

The pump had a capacity of 134 gallons per minute, or 180,000 gallons per day, (eight hogsheads per hour as given in the old records).

Many of the account books and other records were destroyed by a fire which destroyed the residence of Arent H. Schuyler, on November 15, 1870. Enough remains, however, for us to abstract the following items:

"1753.	
Oct. 25—To carting 624 bushels lime to ye mine for ye engine house,	£ 2 - 0 - 0
To carting 66 days, clay and stone & 300 boards to ye mine 6 s. per day,	£19 - 16 - 0
To 11 days carting 3000 shingles and ten thousand bricks &c to ye mine,	£ 3 - 6 - 0
"Dec. 28—To cash pd for 16 days carting timber to ye sawmill & mines for ye engine house at 6 s.	£ 4 - 16 - 0
"1754	
Jan. 8—To 6 days slaying timber for ye engine,	£ 1 - 16 - 0
"Feb. 24—To 10 days slaying stone and timber for ye engine,	£ 3 - 0 - 0
"Mch. 1—To cash pd for carting timber for ye engine house,	15 - 0
"Apr. 2—To cash pd for sashes in the engine house,	10 - 6

"June 13—To cash paid Josiah Ward for 1 days carting fire stone for ye engine from the mountain, 8 - 0

132 days carting stone & timber for the engine house at 6 s. per day £39 - 12 - 0

"July 15—To pd Elizabeth Davis for a tree for ye engine house, 10 - 0

2 days carting, 12 - 0

"Oct. 10—To pd Thos. Childs for 1 1/2 days mason work at the engine house 9 - 0

"Oct. 28—To pd Thos Plummer & Thos. Barnes for putting the boiler at ye engine house together, £35 - 1 - 6

"1755
Jan. 11—To pd Benj. Smith for work done on ye engine house, as per his acct. & receipt. £52 - 5 - 6

"Mar. 12—To 52 days carting stone & fire wood for ye engine, £15 - 15 - 0"

The engine was, therefore, probably started some time in March, 1755. The shaft was 100 feet deep at that time, and was carried deeper as the work of mining progressed, until, owing to the increasing flow of water, the engine was no longer able to keep the mine dry. This shaft was then abandoned and other shafts were worked to some extent; but, within a few years, operation was entirely abandoned.

Up to the time when this shaft was sunk (about 1735), the mining had been done by drifts into the side hill; some of the other shafts upon the property were undoubtedly sunk between this time and the arrival of the engine.

In 1761, Hornblower and John Stearndall leased the mine from Schuylers—agreeing to pay one-seventh of the ore as rent—for fourteen years, the lease being afterward extended ten years longer.

On March 25, 1765, Stearndall & Hornblower assigned one-half their interest to Philadelphia parties; John Kidd, William Parr, Judah Fulke, and William Dowell. These worked it until 1768. During 1768 and 1769, it lay idle, but it was

started again by New York operators and kept up till 1773, when the engine house was destroyed by fire.

After this, no work was done for twenty years, except surface digging. For the years named herewith, the account books of Hornblower show that the receipts from the mine were: 1765, £670, 7s. 9., New York money; or in dollars, $1,676; for 1766, $4.357.87; for 1770, $4,785; for 1771, $7,787; for 1772, $1,237; for 1773, $2,855. Ore brought from $8 to $10 per 100 pounds.

In 1770, only forty-one tons of copper ore were exported from America, being valued at £853, 13 shillings sterling, or less than £21 per ton.

An officer of the Continental Army in a Massachusetts regiment, stationed in New York in 1776, in a journal kept by himself and Isaac Bangs, gives an account of visiting the celebrated copper mine. He, with two other officers and eighty men, was detailed to go into New Jersey and cut timbers with which to obstruct the harbor against the enemy's vessels. They were provided by Schuyler with a guide, with whom they visited the celebrated copper mines, the engine house being then in ruins, having been burned by a discharged workman four years before..

Work was begun a short distance west of Hackensack river, in a cedar swamp belonging to Arent Schuyler; this swamp is now obliterated, the only traces of its location consisting of old stumps and tree trunks submerged beneath the level of the meadows on either side of the Jersey City and Belleville Turnpike.

The road leading to Schuyler's homestead was built by Hornblower in 1765, and was used at this period by the Colonial troops as a military road. It formed the principal means of communication between New York harbor and inland New Jersey. The cedar swamp was so dense that Hornblower was obliged to do most of the survey work by the aid of lanterns.

The Schuylers, as well as the Hornblowers, were ardent patriots; and Hornblower did not return to England, as was his first intention, but remained in this country and married Miss Kingsland, whose father's plantation adjoined that of the Schuyler's. It may here be remarked that the late highly honored and esteemed Chief Justice Joseph C. Hornblower,

who was born in Belleville, and died in Newark, full of years and distinction, in 1864, was the youngest of a family of twelve resulting from this union.

This was really the first mine of any value that had been discovered after nearly a century of prospecting.

When first worked the yield averaged about 100 tons per annum, and the mine was highly profitable. *Gordon's Gazetteer* says: "From the books of the discoverer, it appears that before the year 1731 he had shipped 1386 tons to the Bristol Copper and Brass Works."

England did not permit the smelting and refining of ore in the Colonies, and there were no facilities for doing machine work, so that the mine lay idle during the Revolution. On February 4, 1793, however, the New Jersey Copper Mining Association (headed by Jacob Mark, Philip A. Schuyler, and Nicholas I. Roosevelt) leased the mine from Arent J. Schuyler (son of Col. John Schuyler, now deceased) for a term of twenty-one years, with the privilege of renewing it for twenty-one more. The rental was fixed at one-tenth of the ore for the first term, and one-seventh for the second; the lessees being required "to erect and rebuild a sufficient steam engine within eighteen months and to keep at least eight men at work for not less than eight months in the year."

On February 5th, 1753, they agreed "for the better carrying into execution their intentions of extending the Copper Works by Erecting Furnaces & Battering & Rolling Mills, Do declare that the works shall be carried on under the name and firm of the New Jersey Copper Mine Association, property represented by 640 shares divided among those interested, 3 directors to be elected annually. The first Election for chusing directors shall be on the first Monday in January after the first steam Engine is Erected, untill which time the whole management of the Company's concerns shall remain with the Lessees." The Directors were authorized to reserve not more than $8,000 annually until $20,000 should be accumulated which was to be invested as capital, and used as necessity might require for the betterment of the company.

Mr. Hornblower was employed to take charge at a salary of $60 per month, with the promise of a one-sixteenth interest in the concern.

Roosevelt, Mark and Schuyler, Directors of the New Jersey Copper Mine Association, bought from Hornblower, August 29, 1794, six acres of land on the brook known as Second river, with the privilege of erecting a dam and coal house. Here they established a foundry and machine shop; and here Josiah Hornblower built for them a stamp mill, the first one in this country, as the shaft where the original engine was set up was also the first to attain any considerable depth or produce ore of commercial value. Both the mill and shop were operated by water power, and to this mill the product of the mine was taken for stamping and concentrating. The walls of the old mill are still standing, and a portion of the water wheel (which was used for driving), as well as the dam, which was built by Hornblower for the needed supply of water power.

Roosevelt named these shops "Soho," after the large establishment in the old country; and it was in this machine-shop that the first steam engine built in this country was made.

The smelting works were in charge of one Smallwood; and John Hewitt[7] and a German named Rhode, were employed here, the former to make patterns and Rhode to make castings for the engine for Chancellor Robert R. Livingston's steamboat, the *Polacca*. This boat started on her trial trip on October 21, 1798, was sixty feet long, and was propelled by a jet of water forced out of the stern by a powerful centrifugal pump. The engine had a cylinder twenty inches in diameter and of two feet stroke.

The management under the new arrangement was not satisfactory to Mr. Hornblower, and in 1794 he retired. The company introduced German miners because of the low wages, but the work was abandoned early in the 19th century; the old engine was broken up and the material disposed of. The boiler, a large copper cylinder with a flat bottom and dome-shaped top, was carried to Philadelphia. This relic (regarding which an article is given in "Atkinson's History of New Jersey," dated 1878, and from which a portion of this account is taken) is a piece of the cylinder about six feet long and four feet in diameter. It finally passed into the hands of David M. Meeker & Son, the malleable and gray-iron founders, and was by them

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[7]An ancestor of ex-Mayor Abram S. Hewitt of New York City.

exhibited at the Centennial Exhibition. In a chapter devoted to "Mines, Minerals, Stones and Fossils" of an early history of the United States, occurs the following: "A copper mine, on the Pasaic, a few miles north of Newark in New Jersey, has been wrought to advantage, and an association by the name of the Soho company, has been incorporated for the purpose of prosecuting the business."[8]

An effort to work the mine in 1833 (when an English company took hold) is referred to by I. Finch,[9] as follows:

"The mines are now reopened, a steam engine erected to drain them, and the works are proceeding with spirit. It is the only copper mine worked in the United States."

The mine was at this time under the supervision of William Tregaskis, and the "Victoria" shaft was reopened to a greater depth and a more powerful engine installed. It is supposed that Tregaskis gave the shaft its name, for in later operations it is always so referred to. It is not known how long this company operated, but it is supposed it found the ore of less value than represented.[10]

The mine was worked in 1855-1856 by a Philadelphia company, for which Mr. Theodore Moss was engineer; but the work done between 1833 and 1859 was but little. Some parts of the mine were worked by a man named Cathuey, but on a contract basis, and for unknown parties.

In 1859, the Brisk company acquired the mining rights and property, but it sunk no shafts. All the shafts upon the property were sunk at some time previous to this. The company, however, opened some of the old shafts and in one of these were discovered an old horse pistol, a silver tea set, and a num-

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[8] "Elements of Useful Knowledge. By Noah Webster, Jun. Esq. Increase Cook & Co., New Haven, 1808." Vol. II p. 86.

[9] "Travels Through the United States and Canada." London, 1833, p. 277.

[10] "In 1833, when a new company was forming to work the mine, it was represented that 'the ore of the principal vein yields from 60 to 70 per cent. of copper, and the vein will produce, it is supposed, from 100 to 120 tons of ore annually, which yields from 4 to 7 oz. of silver to the hundred pounds; and, like most copper ores, a small portion of gold. When pure copper was sold in England at £75 sterling the ton, the ore of this mine was shipped from New York for that market at £70 the ton.' (£70 N. Y. Currency—$175)." (*Gordon's Gazetteer*, p. 12.)

ber of silver spoons, bearing upon them the names of some of the old families throughout this section. The find was probably a portion of some robber's plunder left there for safe keeping, and for some reason never removed. Brown, mine captain for the Brisk company, operated the mine from 1859 to 1865 with much of the old machinery. At this time it was known as the "Victoria Copper Mine," and there were about 200 men employed as miners, laborers, and workers in the mills. In 1865, presumably in February, an accident happened to the pump; before repairs could be made the water rose so high that the proprietors stopped work, thinking that improved processes would enable the treatment of the ore in this country instead of sending it to Swansea, Wales, where all the ore was formerly sent. The mine was abandoned and many tools were left in the lower drifts, as the water began to rise before the miners had an opportunity to collect them.

The Victoria shaft is reported to be 347 feet deep, but all is mud below the 240 foot level and difficult of access. The old Cornish pump is still in position at the bottom of the shaft, buried in mud and fallen timbers. It is said that there are three drifts from the bottom of the shaft, one toward the northwest about 180 feet long, one running southwest 180 feet long, and the third running north about 210 feet. The mill at this time was near the mine and had twenty-five stamps of the old Cornish type with wooden stems. The ore as it came from the mine was cobbed and hand-picked. The high-grade material was shipped without further treatment, and the lower-grade was concentrated by means of jigs and buddles. When the Brisk company ceased operations, their engine house caught fire during the night and burned down. The machinery, antiquated even for that time, was inefficient, and the company quietly passed out of existence. They worked, however, too near the surface in one portion of the mine, and in 1866 a cave-in occurred, now known as the South cave-in, engulfing a barn which was built over it on the surface.

In 1892, a company, known as the New York and New Jersey Mining Company, endeavored to work the mine, but its capital was not sufficient. It robbed the pillars where some of the best ore had been left, brought the surface down in another cave-in, and ceased operations.

In the fall of 1899 an option was secured upon the property, and the three interested parties made examinations and cleaned out two of the old shafts. They afterward promoted a company, known as the Arlington Copper Company, and capitalized at $2,500,000, to operate the mines. With this company the author was, for a time, connected, as engineer in charge of construction, but resigned before the end of a year.

The material "has not proved as susceptible to the proposed chemical treatment as was expected." The money "was expended under the direction of an 'expert' in the installation of a plant of unique design, with good machinery, but no local metallurgical value. When run on the ore it was found that the tanks would not hold the solution and the copper would not precipitate."[11] Part of the older portion of the mine is at this writing being worked as a stone quarry; the sandstone has a commercial value as a building material.

The geological formation is Triassic, gray and red sandstone and shale, with intrusive trap dikes. The sandstones are inclined at an angle of about 9° to the horizontal; the trap is partly brecciated and often forms, with the sandstone, a metamorphic conglomerate. The ore is the cuprous sulphide, chalcocite (Cu_2S) and the carbonates malachite and azurite. (Azurite is rare.)

The first mentioned carries about 78 per cent. and the two latter about 57 and 55 per cent. of copper respectively, when pure. Therefore, the original discovery on the outcrop must have been a piece of chalcocite. Small quantities of cuprite or red oxide, and of copper silicate are also found; as well as minute (and scarce) particles of native copper. "The ore itself is not in any vein with well marked boundaries, but occurs in pockets, or bunches, and seams which ramify through two thick layers of sandstone and a thin bed of shale. There are numerous faults in the deposit, and it is at these points and in connection with small trap dikes that some of the richest ore is found. There is a considerable shaly slate which assays from six to seven per cent." The ore also occurs "as finely scattered particles,[12] or as thinly diffused coloring matter."[13]

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[11] Annual Report of the State Geologist, Trenton, N. J., 1902.
[12] In the shale and sandstone. [13] In the sandstone. (J. H. G.)

Forty-two shafts in all have been sunk at various times and places, many of them connecting with passages of the most tortuous character; eight of them connect with the three drain tunnels which have been run for unwatering the mine. The longest of these tunnels is 1300 feet in length, and connects through a drift with three large chambers that have been stoped out. One of these measures 670 feet in perimeter.

The mine has been the producer of other things than copper. Nearly a score of years ago it was the scene of a novel depicting the woes of one "Maggie Tilby," who is actually reputed to have made the abandoned workings her dwelling place and to have earned the title of "witch" in consequence. It is also reported to have served, during the Revolution, as a hiding place for the spies in the Colonial Army; even now it has, what lonely and abandoned spots seem always to obtain in time, a "haunt."

The ghost stories are, seemingly, not confined to the rosy descriptions of the promoter. Since early in the 19th century, most of the working appears to have been of the public rather than of the mines; and for the past three years, the entire establishment has been idle, a prey of the speculator and the cause of much disappointment and legal quibbling. It may be that the days of its usefulness as a producer of copper are over. Certain it is that where a hundred and fifty years ago teamsters were carting "fire stone" to the historic engine, a settlement of the distinctly modern suburban type is fast obliterating the last traces of the old land marks.

In a paper covering a subject of such historic interest, the author must, of necessity, become more or less a compiler. Acknowledgments are due for much of the information contained in the foregoing, to various reports of the State Geologist of New Jersey, to a paper on "Josiah Hornblower," read by William Nelson before the New Jersey Historical Society at Newark, May 17, 1883, and to Mrs. Cortlandt Van Renssallaer.

(*To be continued.*)

THE FRANKLIN INSTITUTE.

(Annual Meeting, held Wednesday, January 16, 1907.)

Work of the United States Reclamation Service.

F. H. Newell, Chief Engineer of the Reclamation Service.

The work of the Reclamation Service is the outcome of what is known as the Reclamation Act, signed by the President June 17, 1902. This Act sets aside the proceeds of the sale of public lands in thirteen Western States and three Territories, converting this into a fund in the Treasury of the United States to be utilized in the construction of works for the reclamation of arid lands, these lands, if public, being given away to men who will live upon them, payment being made for the actual cost of bringing water to the land. The repayments for this water are turned back into the Treasury and become immediately available for the construction of other works.

In short, the Reclamation Act creates a revolving fund which, if well administered, should grow continually, to be utilized until all of the arid lands of the West have been reclaimed.

The estimated funds from 1901 to 1908 amount to a little over $40,000,000. Plans have been made for the investment of this entire amount and work begun on large structures at various points in the arid West. About twenty-four projects have already been begun, after approval by the Secretary of the Interior, who is the official charged by law with putting the Act into effect.

To assist him in this matter the Secretary of the Interior has what is known as the Reclamation Service, an organization of about 500 skilled engineers and assistants. These men have studied the situation, made surveys and preliminary designs, and after these have been approved by the Secretary of the Interior, have begun work of construction, the operations in general being carried on by contract in the customary manner. It has been found, however, that the price of material and labor has advanced so greatly within the last year that many of the contractors have

been financially embarrassed or have failed. As a result it has been necessary for the Government to take over the works and complete them by what is known as "force account." In the case of other large works, bids for which were asked, there have been no bidders, or the prices offered have been so high as to render it impracticable to award a contract. In such cases the Secretary of the Interior has authorized construction by force account, it being ascertained that this can be done by the present organization, as a rule, cheaper than by the usual form of contract. The conditions are somewhat anomalous; but with a rising market for labor and material it becomes exceedingly difficult for even the best equipped contractor to make estimates which will allow him to realize a profit, especially when the work is carried on through several years.

One of the features of the Reclamation work to which especial care has been given is that of cost keeping, not only to ascertain the total cost of the work, but also the unit cost of each important operation. These costs are kept not only for the work which the Government itself is carrying on by force account, but also for the contractor, so that it is possible to compare the actual cost of the work to the contractor and to know from time to time whether the contractor is making or losing money. This is an important detail in any Government work of this character, as the responsible men in charge should know whether the contractor is in a financial condition such that he can bring the work to a successful conclusion. Otherwise, plans must be made for taking over the work, if the contractor will not be able to push it successfully.

It is also important that the Government and the people interested know exactly what the work is costing, so that there may be no misapprehension on the part of any one as to the ability of the Government to handle its own work by a thoroughly trained civil service. It is believed that the results accomplished demonstrate this fact, namely, that it is possible by careful selections under civil service laws to obtain men of high character and ability and by the promotion of these and recognition of their work to create an organization capable of handling Government work economically and effectively.

The following brief statement gives the larger features of each of the projects in the various Western States and Territories.

These are arranged alphabetically by the name of the State. It should be pointed out that each project differs from all others and that each offers peculiar problems difficult of solution. One of the greatest obstacles to be overcome in the organization of the Reclamation Service is due to the fact that the work is so widely distributed that it is practically impossible for one man to see all of the work even if he should travel continuously for nearly a year. It has thus been necessary to select for supervising engineers in the field men of large ability and to give these men discretion in detail such as would hardly be given to subordinates in

Site of the Roosevelt dam, Arizona.

the case of works which are concentrated within the limits of one State or which could be reached within a few hours' travel.

In this respect the difficulties met by the Reclamation Service are more extreme than those at Panama, where the work can all be inspected within reasonable time and where it all lies on a railroad and covers an area of about forty miles only in extent. Many of the Reclamation projects with regard to area are far larger, some of them extending for a length of nearly a hundred miles and without railroad facilities.

Arizona.—The Salt River project contemplates the construction of a large storage dam, 270 feet in height, at Roosevelt, Ariz., which will regulate the supply of water by gravity system for about 160,000 acres of land in the vicinity of Phœnix. When the dam is constructed there will be developed a large amount of power, which will be utilized to increase the water supply in the Salt River Valley by means of pumping from underground sources.

A cement mill was erected by the Government and is now in operation, furnishing a first-class quality of cement to be used in the works. The construction of the dam will require 200,000 barrels of cement. The lining of the power canal and the work on the sluicing tunnel are finished, and the work on the large dam is being pushed.

California.—The Yuma project is for the diversion of the waters of the Colorado River, by means of the proposed Laguna dam and sluiceways, about ten miles northeast of Yuma, Ariz., into two canals, one on each side of the river. In Arizona these canals will irrigate all the bottom lands of the Colorado and Gila rivers, between the Laguna dam and the Mexican boundary (84,000 acres in round numbers), and in California the bottom lands in the Yuma Indian Reservation (17,000 acres). Plans also contemplate the construction of a complete system of levees to protect the bottom lands from overflow and a pumping system to remove the surplus water from the low-lying areas.

Colorado.—The Uncompahgre Valley project contemplates the diversion of waters of Gunnison River by means of a tunnel 30,000 feet in length, cross section 10½ by 11½ feet, cement-lined, capacity 1,300 second-feet. The tunnel passes under a high divide and carries the water to Uncompahgre Valley, where it will be utilized for the reclamation of 140,000 acres of land in Montrose and Delta counties. Construction of the tunnel was begun in 1904 and work thereon has since been progressing rapidly. More than 3½ miles are completed.

About twenty per cent. of the irrigable land is subject to homestead entry under the provisions of the Reclamation Act. The farm unit for first-class fruit land will probably be forty acres, while on other lands suitable for growing grain, sugar beets and alfalfa eighty-acre tracts may be filed upon. No water can be delivered for irrigation prior to the crop season of 1909.

Idaho.—The Minidoka project provides for the reclamation of about 130,000 acres of land lying on both sides of Snake River in Southern Idaho. The area to be benefited was all Government land, which has been withdrawn from general entry under the provisions of the Act of June 17, 1902, but remains subject to entry under the provisions of the Homestead Law. Homestead entries within a radius of 1½ miles from the center of each town site established are limited to forty-acre tracts, and those on all other lands under this project to eighty acres. The soil is excellent, being a deep, sandy loam free from alkali, now produc-

Gunnison Run, at head of tunnel taking water into Uncompahgre Valley, Colorado.

ing a thrifty growth of sagebrush. The cost of water right under this project will be \$25 to \$35 an acre, to be paid in ten annual installments, without interest. It is believed that all of the land is now filed upon by bona fide settlers.

The large dam is completed; the telephone system is finished, and work on the distributing system is being pushed vigorously. Present conditions indicate that water will probably be turned on the lands under the gravity canals in the irrigating season of 1907.

The lands to be included under this proposed system are tributary to the Oregon Short Line Railway, which has recently extended a branch line through the Minidoka tract, upon which are located three town sites, the lots in which are offered for sale by the Government.

The Payete-Boise project ultimately will reclaim about 370,000 acres of land in the valleys of the Payette, Boise and Snake Rivers, in Southwestern Idaho. Of this area about five-sixths is without present facilities for irrigation. The complete plans propose the utilization of both the Payette and Boise Rivers and include the construction of extensive storage works at the headwaters of each stream. The lands are smooth, with gentle slope to drainage. The work of construction has been taken up by units and several years will elapse before the whole project is completed. Several contracts have been let and the work is now under way.

Kansas.—The Garden City project, by means of an extensive pumping system, will provide a supply of water to irrigate about 8,600 acres situated just east of Deerfield, in Southwestern Kansas. The land in question is all in private ownership and is under an existing system owned by the Finney County Farmers' Irrigation Association. The attempt to furnish water for the irrigation of these lands by a gravity system supplied by diversion from the river has not met with success, owing to the rapid loss of water from the river to the gravels and the uncertain volume of flow in this stream.

The proposed pumping plant is designed for the recovery of underground waters and involves the construction of twenty-three separate pumping stations, each driven electrically from a central power station.

Montana.—The Huntley project is one for the reclamation of about 30,000 acres of land located along Yellowstone River in Southeastern Montana, within the ceded portion of the Crow Indian Reservation. The lands to be reclaimed are along the Northern Pacific and Chicago, Burlington and Quincy Railroads. They form a portion of the area which the Crow Indians, by treaty ratified by Act of Congress approved April 27, 1904, ceded to the United States. Upon the completion of allotments to the Indians as required by the act, the area remaining is to be subject to disposition in accordance with the provisions of the home-

stead laws and the rules and regulations governing the disposal of public land. In addition to the cost of reclamation, the price of the lands is to be $4 an acre when entered under the homestead laws.

The *Sun River* project was formally approved by the Secretary of the Interior on March 19, 1906, and the sum of $500,000 was allotted for initiating the work of construction. The preliminary investigations indicate that in the Valley of Sun River 256,000 acres are reclaimable, a large percentage of which is public domain. The irrigable area is a broad prairie extending from Teton River on the north to Sun River on the south, a distance of thirty miles, and from the Rocky Mountains on the west to Missouri River on the east, a distance of seventy miles.

This land, although extremely rich in all the elements of fertility, without water is only fit for grazing, but when irrigated will be very productive. The examinations made by the engineers show that this project is free from difficult engineering features, and the topography of the country is such that it can be built a unit at a time. It is possible that the first unit selected for construction will be the reclamation of about 16,000 acres.

Nebraska-Wyoming.—The North Platte project has for its object the storage of the flood and surplus waters of North Platte River in a reservoir in Wyoming by a dam 210 feet high in a narrow canyon just below the mouth of Sweetwater River. During the irrigating season the water will be permitted to flow down the channel of the river for about 150 miles to where a low diversion dam will turn it into canals, which will distribute it over the lands to be irrigated.

The land to be reclaimed is fertile and adapted to the successful growth of a wide variety of crops. Water will be delivered for the irrigation of a considerable portion of the land under this project during the season of 1907.

The Pathfinder tunnel has been completed and contracts have been let for the construction of the Pathfinder dam, for the excavation for about ninety-five miles of the Interstate canal, and for re-enforced concrete structures on its first forty-five miles.

Nevada.—The Truckee-Carson project, when completed, will provide an ample supply of water to irrigate about 350,000 acres of arid land in Western Nevada. The first work of actual construction was begun in September, 1903, on a canal thirty-one

miles in length, to divert water from Truckee River and convey it to the channel of Carson River, where a storage reservoir will eventually be built. This canal, with several hundred miles of lateral ditches, is completed, and on June 17, 1905, the third anniversary of the Reclamation Act, occurred the formal opening of this project, the first to be constructed under the authority of the law of June 17, 1902.

Water is ready for delivery to more than 100,000 acres, the greater part of which is public land, which has been thrown open to homestead entry, and may be filed upon by bona fide settlers, in accordance with the rules and regulations of the homestead laws and Reclamation Act. An assessment of $26 per acre will be charged against the land for its water right, payable in ten annual installments, without interest.

The construction of outlet and regulating works at the outlet of Lake Tahoe and the extension of the system to include additional areas will be undertaken at an early date.

New Mexico.—The Hondo project, completed in 1906, diverts and stores the water of Hondo River, a tributary of the Pecos, and will make possible the reclamation of about 10,000 acres of land in the vicinity of Roswell.

The Carlsbad project includes storage reservoirs in Pecos River in Chaves County and the extension of canals which have been constructed by private enterprise to irrigate about 20,000 acres of land. The development of Pecos Valley has been brought about by individuals, who installed an extensive system of irrigation works, representing the outlay of more than a million dollars. On October 4, 1904, a flood in Pecos River destroyed a large portion of Avalon dam, upon which the canal system depended for its supply. The owners of the canal system were unable to repair the damages, and, as property valued at not less than $2,000,000 was threatened with destruction unless the water supply was provided, an appeal was made to the Government to take the works and to initiate construction in order to prevent the destructions of homes and property. Construction has been begun. The land under this project is now mostly in private ownership.

New Mexico-Texas.—The Rio Grande project involves the construction of a storage dam opposite Engle, N. Mex., across the Rio Grande, which will form a reservoir 175 feet deep at its

lower end and forty miles long, with a storage capacity of 2,000,-000 acre-feet, for the irrigation of 180,000 acres of land in New Mexico, Texas and Mexico.

The Leasburg division, which is a part of the Rio Grande project, calls for the construction of a low 500-foot concrete diversion dam, with pier, embankment and sluice gates, head weir, and head gates. In connection with the diversion dam it will be necessary to construct six miles of full-size canal to connect with the old Las Cruces canal.

North Dakota.—Three pumping projects are planned in West-

Complete portion of concreted lined canal through rock cut on Truckee Canal Nevada.

ern North Dakota for the purpose of raising water from the Missouri River to irrigate bench lands which lie at heights too great to be reached by gravity systems. Both steam and electric power will be used for pumping, the power to be developed from lignite coals which are found in ample quantities near by.

Buford-Trenton project.—This project, located about twenty miles west of Williston, on the Great Northern Railroad, will supply water for a series of flats aggregating about 27,000 acres.

Williston project.—The pumping plant for this project will be located about five miles west of Williston and about twenty-five miles east of the Montana-North Dakota State line. Forty thousand acres of bench land on the north side of the river will be irrigated, but the system is capable of extension to flats on the other side of the river, making a total of approximately 70,000 acres. It is proposed to pump all the water required from the Missouri River into the low-line canal at the main plant, and to pump from this main canal into canals at higher elevation by means of electrically operated plants conveniently located.

Nesson project.—The area to be covered by the Nesson project consists of about 25,000 acres of bench land situated thirty miles east of Williston, the larger part being on the north side of the Missouri River. About twenty-five per cent. of the land is in Government ownership.

North Dakota-Montana.—The Lower Yellowstone project takes water from Yellowstone River at a point seventeen miles northeast of Glendive, Mont., for the irrigation of 66,000 acres of land lying in Northeastern Montana and Northwestern North Dakota. Work is in progress on the main canal and lateral system.

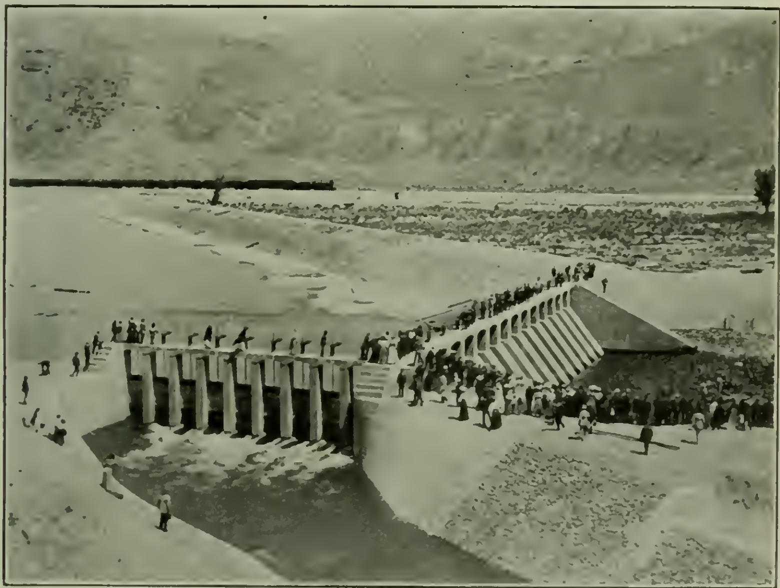
Oregon.—The Umatilla project embraces 20,000 acres immediately south of Columbia River and east of Umatilla River. About ten per cent. of these lands are in public ownership. The engineering work in connection with this project consists of a feed canal from Umatilla River to the Cold Springs reservoir and a distribution system. The works are of simple character and capable of being constructed in a short time. The irrigable area under this project lies below 500 feet in altitude, is rolling in character, and the lands are of high fertility. The climate is warm and the soil adapted to orchards, small fruit and vegetables.

Oregon-California.—The Klamath project lies across the State line in Southern Oregon and Northern California. The total irrigable area under this project embraces 236,402 acres, of which forty-five per cent., or 106,829 acres, is public land, and 55 per cent., or 129,573, is private land, 90,000 acres being in California and the remainder in Oregon. The lands are of excellent quality, and alfalfa, wheat, oats, barley, rye, vegetables and the deciduous fruits are grown successfully. Experiments in the culture of sugar beets show that this crop may become a

profitable industry. The project naturally falls into two distinct parts—the so-called "upper project," provided for the irrigation of lands in Langells, Yonna, Poe and upper Klamath Valleys, and the "lower project," which includes the irrigation of lands in Klamath and lower Poe Valleys, and the reclamation of lower Klamath and Tule Lakes by drainage.

Contracts for the construction of the main canal and the auxiliary works have been let and construction of the system has begun.

South Dakota.—The Belle Fourche project, when completed,



Dam and headgates, Truckee River, Nevada.

will reclaim about 100,000 acres lying northeast of the Black Hills, Butte and Meade Counties, S. Dak. Of the total irrigable area it appears that about 50,000 acres is public or Government land.

Work on the main supply canal, the dam, and distributing canals is progressing steadily. It is expected that the south side canal, which will furnish water to irrigate about 20,000 acres, can be constructed in time to deliver water in 1907.

Utah.—The Strawberry Valley project provides for the irrigation of about 50,000 acres of land in Central Utah, situated from

five to fifteen miles south of Provo and on the eastern shore of Utah Lake. Water supply will be received from a storage reservoir to be built on Strawberry River, about thirty miles east of the irrigable area. By means of a tunnel four miles long the stored waters will be carried under the divide and emptied into Spanish Fork, from which a canal from eighteen to twenty miles long will convey them to the irrigable area. The lands have a mean elevation of 4,500 feet.

Washington.—The Okanogan project is designed to supply water to 8,650 acres of land in Okanogan Valley, in Northern Washington. The water supply is estimated to be sufficient for the proper irrigation of 10,000 acres, 1,350 of which are now supplied. The farm unit has not been definitely fixed, but a soil survey is being made, and it is believed that on account of the possibilities for high development in this section the area allowed each settler will be restricted to forty acres.

Yakima Valley contains an area of approximately 500,000 acres; with storage it is estimated the water supply is sufficient for 340,000 acres. This acreage includes approximately 100,000 acres in the Yakima Indian Reservation, which can be brought under canals at a moderate cost, but for which there is no late summer flow in the river. The development of a comprehensive system of irrigation in Yakima Valley can be accomplished by the successive construction of several units of a general project, the work being graduliay extended to embrace the entire irrigable area.

The Tieton division, which is an integer of the great work projected in Yakima Valley, embraces an area of about 24,000 acres west of and near the city of North Yakima. The water supply will be from Tieton River, supplemented by waters stored in Bumping Lake

The Sunnyside division of the Yakima project contemplates the enlargement and extension of the Sunnyside canal system now in operation, and in connection therewith the construction of suitable storage works at the upper Yakima Lakes. The canal and lateral system contemplated as the first section of the work will irrigate about 40,000 acres of land. Construction of the Tieton and Sunnyside projects will begin in the spring of 1907.

Wyoming.—The Shoshone project provides for the diversion

of a portion of the waters of Shoshone River, and the construction of an impounding dam at the head of the canyon through which the river flows. The reservoir thus created will have a

Shoshone Dam Site, Wyoming.

storage capacity of 456,000 acre-feet. When the project is completed, it will be possible to reclaim about 175,000 acres of irri-

gable public lands. A portion of this area, 122,000 acres in extent, is located on the left, or north side of the river, and 53,000 acres on the right, or south, side, the whole being about seventy-five miles east of Yellowstone National Park, Wyo.

The soil is productive, and hay, wheat, oats, barley and the hardier vegetables can be produced abundantly with an ample supply of water. At the proper time, when the construction of the project is approaching completion, the lands will be thrown open to homestead entry by bona fide settlers under the homestead laws and terms of the Reclamation Act.

Construction work is well under way on the outlet tunnel, temporary diversion works at the dam, and Corbett tunnel.

THE AMERICAN GALVANIZING COMPANY.

A company is now being formed by H. W. Poor & Co., 33 Wall street, New York, named the American Galvanizing Company, for the purpose of introducing in this country the process of dry galvanizing which is known as Sherardizing. This new process of galvanizing is in successful use in Great Britain and Germany, and has received considerable attention in the technical press. In this process the articles to be galvanized are placed in a closed iron receptacle filled with zinc dust and heated to a temperature of 500 to 600 degrees F. (200 to 300 degrees below the melting point of zinc) for a time varying from a few minutes to several hours, according to the size of the article treated, and are then allowed to cool. The articles treated are then found to be coated with a fine homogeneous covering of zinc, the thickness of which is dependent upon the temperature and the time for which the article has been treated. The covering effected in this manner is not merely superficial, but is claimed to be alloyed into the surface of the article treated. It is then impossible to separate the zinc either chemically or mechanically without removing the original surface of the article treated. It is claimed that by this process the required plant is much cheaper than a plant for hot galvanizing; a great saving in fuel and labor is effected; a less amount of zinc is required; a coating of any desired thickness can be given; the surface is much smoother; a high polish equal to nickle plate can be given at very little cost; there is no loss in temper or of tensile strength; screws do not require to be rethreaded after treatment; large articles, such as structural shapes, can be treated.—*Iron Age.*

(*Stated Meeting held Wednesday, November 21, 1906.*)

The Why of the Weather.

Harvey M. Watts.

[Abstract.]

Mr. Watts, with the aid of lantern slides, showing weather maps, storm tracks and the general circumpolar weather drift, as well as photographs of the Blue Hill Observatory connected with Harvard University, where the sounding of the ocean air by means of kites has been carried on so successfully for over ten years, and the new Mount Weather Observatory of the United States Weather Bureau, of which so much is expected, developed the general theory now held by leaders in the meteorological world as to the cause of variations in weather and climatic conditions.

Mr. Watts pointed out that the science of meteorology was on the verge of a great advance; first through the possibility of a general daily survey of pressures the world over, which would allow a synoptic chart of the entire northern hemisphere to be made; and, secondly, through clearer understanding of the relation of variations in the sun's radiation to seasonal changes in terrestrial weather and climate.

The general synoptic chart giving pressures for the northern hemispheres naturally would be the first step toward extending daily forecasts so as not only to cover twenty-four hour periods, but forty-eight hour periods and even periods of a week or more. This would be possible since the weather drift in the northern hemisphere above the tropics being eternally from West to East, in a great circumpolar swirl, the position of storm-tracks and their intensity depends entirely on the intensity of the travelling barometric pressure centres interacting with variations in the extent, intensity and location of the so-called permanent areas of high and low pressure. Once the pressures and all the meteoro-

logical elements all over the circumpolar area north of latitude 30 are known, the weather to the eastward of any given condition can be predicted with more or less accuracy for several days and on special occasions for relatively long periods.

For instance, a more accurate knowledge of the pressures lying over Siberia, China, the mid-Pacific and Alaska, in connection with the pressures over India and Eastern Europe, would enable one to make very much more accurate forecasting for the United States, since the movement of the traveling areas of high barometric pressures (anti-cyclones) and low barometric pressures (cyclones)—the two eddies into which the general circumpolar drift breaks up—eastward over the United States, is determined by these antecedent conditions lying west of the Pacific Coast.

The subsequent pathway across the United States, and later toward Western Europe, is due to a further interaction with the permanent areas of high pressure lying over the Atlantic. And again, the extent and position of this Atlantic anti-cyclone is in turn a resultant of the interactions of pressures further eastward. It is this inter-dependence of pressures, which condition weather the world over, that makes a synoptic chart of the whole northern hemisphere so important a basic condition of any improvement in weather forecasting for periods within a week or less.

As to improvements in seasonal forecasting, with anticipations of the climatic variations, which are such constant features of the seasons in the north temperate zone, Mr. Watts showed that this long range forecasting of seasons could only come through a study of the variations in the solar radiations, which variation was to be the subject of research at the superb observatory which the United States is building on the top of the Blue Ridge on Mount Weather, Virginia.

The speaker said it must be clear to any one who gave the matter thought that if the sun's radiant output were a constant, with the land and water masses of the earth being what they are now from all historic periods, the variation in climatic conditions from year to year should be insignificant. As a matter of fact, however, we know that the variations are often of an extraordinary character. In any one given year, for instance, the central regions of the United States might experience a summer of extraordinary dryness and intense heat, while the next year the very same region might experience a cool and wet summer or a cool

and dry summer, or any combination possible in weather conditions.

Mr. Watts pointed out that the hot summer type was due entirely to an increase of the pressures in the sub-tropics, south of thirty degrees of north latitude. A summer of this type in the United States meant a strong persistent circulation of air from the South with the interiors baked under excessive sunshine and hot sirocco winds which have been known to blast vegetation in twelve hours. The relation of such contrasts in seasons to the solar variations, he declared, was being worked out by a number of specialists, among them being Prof. F. H. Bigelow, of the United States Weather Bureau, and he said in general the belief which was obtaining credence among meteorologists was that not only must the variation in the quantity in the solar radiation be taken into account, but a variation in the quality, in the matter of its electrical and magnetic as well as mechanical effects.

The way in which the solar variations affects seasonal changes is seemingly through a variation of the intensities of the subtropical pressures. With the sub-tropical pressures strong the south to north circulation tends to rule the northern hemisphere, while when the sub-tropical pressures are less intense the tendency is for the north to south circulation to be more insistent, the paths of the traveling cyclones and anti-cyclones coming further south in both the winter and the summer, with consequently marked variations in what are known as the seasons and also marked changes in the local weather phenomena.

Mr. Watts then called attention to the character of the research into the upper levels of the atmosphere, which play an important part in the questions of the variation of pressures, temperatures and moisture and the formation of rain and general storm and clear weather phenomena. Pictures of the kite flying at Blue Hill, where self-recording instruments were carried over fourteen thousand feet in the air, were shown, as well as pictures of the balloons used at Mount Weather for sounding the air, along with pictures of the Administration and Magnetic Buildings now in use at the Mount Weather Observatory. The Magnetic Buildings at Mount Weather are the most perfectly equipped in the world, Prof. Willis L. Moore having profited by the experiences of other countries, and having adopted and improved upon the instruments in use elsewhere.

It is through studying the variations in the magnetic field of the sun, along with the physical changes going on there, that the correlation between changes in the sun and changes in the weather and climate on the earth will be worked out. As things went, the speaker looked for a great advance in the solution of meteorological problems along the two lines laid down by him, better forecasting for short and long periods and a firmer grip on the cause of variations in climate from year to year.

The Worth Bros. Company, Coatesville, Pa., recently rolled in one of its plate mills eighteen copper ingots, each weighing 6300 lbs., into plates 122x216½ in. and 63-100 in. in thickness. These plates were rolled for the Baldwin Locomotive Works, Philadelphia, Pa., and are the first plates of that kind ever rolled by the company. It is understood that they will be used to line boilers of locomotives, which are being made for export to France. Eighteen more plates of the same size will be rolled at an early date for the same purpose.—*Iron Age.*

The construction of a destroyer, with 30,000 hp. in five gas engines, each propelling a screw, it is announced, is to be started by Lewis Nixon, following the lead of the British Government, which is at present building a destroyer of 1800 tons displacement, to be propelled at a maximum speed of 36 knots, by steam turbines of 30,000 hp. The maximum speed of this new vessel it is said will be 33 knots, while it is announced that a sufficient quantity of fuel will be carried to enable the craft to cross the Atlantic to England at a speed of 30 knots, or in four days. The great difficulty with regard to this part of the programme is based upon the fuel consumption of the engines. Many destroyers are afloat which could accomplish this feat were only this phase of the subject absent. It is stated that in the present case, however, the gas engines, which are each of 6000 hp. (the largest marine gas engine heretofore built is 500 hp.) will be so economical as to make possible the projected transatlantic trip at a speed greater than has ever yet been deemed possible.—*Iron Age.*

The production of aluminum in the United States in 1906 was 14,350,000 pounds. It is expected that the output in 1907 will be twice as much, and that the output of 1908 will double that of 1907. Aluminum has often been spoken of as a possible competitor of copper, but up to the present time its production has been too small to make it a matter of serious consideration in that respect. However, it appears as if conditions may be different by 1908. Few realize that, outside of iron, steel and copper, perhaps no other metal has the possibilities before it that aluminum has.—*Eng. and Min. Journal.*

Section of Physics and Chemistry.

(Stated Meeting held Thursday, April 25th, 1907.)

A New Color Meter.

By Frederic E. Ives.

It has long been recognized that a universal color meter, capable of measuring all colors and expressing them in numerical terms, must be based upon the principle of Clerk Maxwell's "color box," in which half of a divided field is illuminated with ordinary white light, while the other half is illuminated by an adjustable mixture of the three simplest colors of the spectrum, isolated bands of pure red, green and blue-violet.

Without any alteration Maxwell's color box could be used for measuring the colors of transparent objects, such as colored glasses and solutions, placed in front of the aperture for direct light, but it is not adapted for the measurement of the colors of opaque objects. It is also necessarily a large and clumsy instrument, that used by Maxwell being of elbow form, several feet in length, and with the adjustments for taking measurements of a complicated character and quite out of reach of the observer at the eye slit.

Although many attempts have been made to devise a color box type of color meter to meet the various requirements in the industries, not one of them has proved successful, and manufacturers have found nothing better for their purpose than a "tintometer," which uses purely arbitrary scales, different and distinct sets of which are made for a large number of trade uses.

The new color meter is a direct vision instrument, the body of which is about 3x4x20 inches in size, with all the operating adjustments controlled by screws a few inches from the eye. A low dispersion grating is used in place of the prisms in Maxwell's color box, and the field is so divided as to be illuminated through a central slit for ordinary light on one side, and

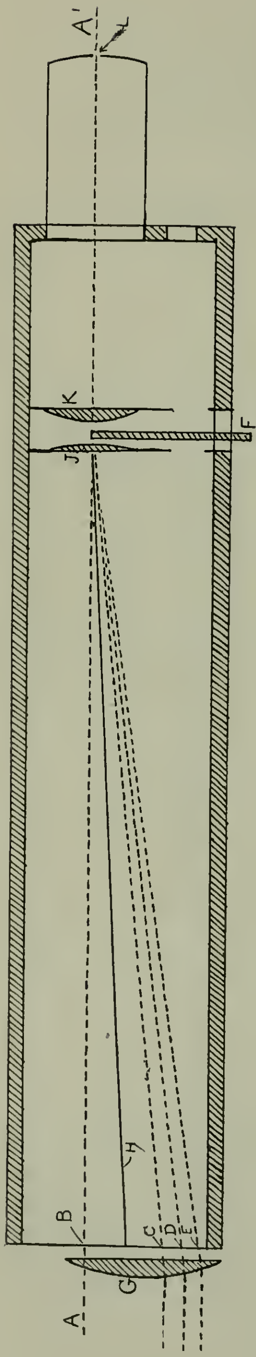


Fig. 1

through three laterally displaced slits for the three-color mixture on the other, while a lens placed in front of the four slit forms an image of external objects which looks like an ordinary single telescopic image divided by a vertical spider line in the eyepiece. The image in the right half of the field is produced in the simplest manner, by light transmitted by the central slit; the image in the left half of the field is formed by mixture of rays transmitted by the three lateral slits, and in using the instrument as a telescope this half of the field would not appear illuminated at all but for the presence of the diffraction grating, which bends parallel to the axis blue-violet rays from the first lateral slit, green from the second, and red from the third, the mixture matching the ordinary white of the right side of the field.

Assuming that the instrument is directed to a surface of standard white, over a portion of which is placed a sheet of colored material to be measured, it will be evident that by so directing the telescope that the colored object fills the right field just up to the dividing line, the left field can be made to match it both in hue and luminosity by suitably reducing the apertures of the color slits. These slits are ruled in a dividing engine, through an opaque film on glass, covered for protection by the thinnest microscope cover glass, and closed by sliding brass plates which are controlled by micrometer screws. Theoretically, the slits should close from both sides towards the middle; but that is a quite unnecessary refinement of adjustment for this instrument. Each micrometer screw head carries a pointer which moves over 100 divisions of a concentric scale to

fully close or open the respective slit, thus reading to one per cent. The scale numbers are read off when the two halves of the field match in hue and luminosity, and recorded as 50 R, 20 G, 60 B, or whatever it may be, as a numerical expression of the color of the object.

Should the shape of the colored object be irregular, the insertion of a thin prism in front of the central slit will displace the image laterally so that a portion at some distance from the edge of the object will come to the inner edge of the divided field, without invading the color mixture half of the field. Very small transparent objects, such as bits of colored glass, solutions in flat glass cells, etc., are placed directly in front of the central slit, and thus made to fill the right field.

The use of a grating in place of prisms in a color meter is believed to be quite new. By no other means would it be possible to make a compact direct vision instrument with a sharply divided field in which one half of an image formed by a single objective is obtained directly through laterally displaced slits, and no other means would permit of such simple and convenient mechanism for taking the measurements.

The obvious objection to a grating is that the conventional type of opacity grating throws a great deal more light into the central image than into any of the spectra, and as only one of the spectra is utilized the illumination would be very much more feeble than with a prism; but it is not necessary to use a grating of this type. Thorp demonstrated the possibility, though not the commercial practicability, of making gratings which throw nearly all of the light into a single spectrum on one side, and the writer can make to order gratings which throw more than 50 per cent. of all of the transmitted light into the first order spectra. It is a grating of this character which is used in the new color meter, with entirely satisfactory results. Many things which have had to receive careful consideration may be best understood after a more detailed description of the perfected instrument and its operation has been given.

Fig. 1 is a vertical plane of the optical part of the diffraction color meter. A, A^1, is a line drawn through the optical axis; B, is the central slit for ordinary light; C, D, E, the lateral slits for blue, green and red spectrum rays; F, the grating, covering half of the field; G, a telescope objective which forms

an image of external objects and background in the divided field; H, a diaphragm to cut light from the central slit out of the half of the field covered by the grating. The lens, J, is of such focal length as to exactly parallelize rays from the central slit B, and the lens K, to converge them to the eye slit at L, from which the field is seen evenly illuminated.

The slits and slit mechanism are all on the outside of the case, and adjusted by micrometer screws acting on levers, conveniently close to the eye. The levers are short and rigid, with a lateral extension and support, because they must work without any wobble or backlash. The obvious method of construction would be to have the micrometer screws act directly upon the slit slides; but that would bring them too far from the eye for convenience of operation, and would also necessitate the use of special differential scales. The use of levers permits of adjustment for different total apertures by simply sliding the micrometer screw mount along the arm of the lever, leaving the scales all alike. These advantages are of such importance that although I at first experienced great difficulty in devising and fitting lever movements that would be "dead beat," I persisted until I believe I have achieved perfect success.

Inasmuch as the setting of the slits must be accurate to $\frac{1}{100}$ of a millimeter, it would be unreasonable to expect such fixtures to retain their adjustment, and provision is therefore made for quickly testing the adjustment and perfecting it in a few seconds if it proves not to be right as found. This, I am convinced, is a wise provision to make, whatever the character of the mechanism, and it serves in this case to permit of such important reduction of cost of manufacture as might very well make all the difference between success and failure as a commercial proposition.

The slit spacing is calculated to superpose wave lengths 43, 53 and 66 on the image of the central slit at the eye slit, when all three of the color slits are half closed; the measurements are therefore made in definite terms. The absolute aperture of the open slits has been found by trial and error, to make the two halves of the field exactly match on a standard background. This is necessary because the extraordinarily brilliant grating used do not give a perfectly normal distribution of light

through the spectrum. This adjustment having been made, a position was found for the bearing of the respective micrometer screws which made them exactly close the slits when the pointer was turned from 100 to 0 on the attached scales, thus dividing each slit opening into 100 parts, although the absolute opening is alike in no two. That the instrument is in adjustment can be proved by several experiments, one of which is to partly close the central slit, when it will be found that the three pointers must be turned down the scale equally to match the white or lower luminosity.

If the color meter be now directed to a house across the street, a single image will appear in the field, with a vertical hair line division through the center, and although the right half of this image is formed through the central slit and the left half exclusively by rays passing through the three lateral slits and then bent parallel to the axis by the grating, making a mixture of red, green and blue-violet spectrum rays only, at the eye point, the two halves of the field may appear exactly alike to the eye. Directed to an evenly illuminated standard white background, the two halves of the field appear exactly alike, of an even, neutral white. The light transmitted by the central slit to the right half of the field is matched in the left half by spectrum red (R) 100, spectrum green (G) 100, and spectrum blue-violet (B), 100.

If, now, that part of the background which covers the right half of the field is covered by a sheet of colored paper, certain kinds and quantities of the colored rays filling the left half of the field must be cut off in order to make the two halves match again, and the quantity remaining is a measure of the color and luminosity of the paper in terms of R, G, and B spectrum rays. Assuming that the scales read R 50, G 20, B 60, this color can at any time be reproduced by pointing the color meter at a standard white background and setting the indicators at those figures, provided that at the time it is done all slits exactly close by turning the pointers down to zero, which can be determined by trial in a few moments. If it is now desired to see if a new sample of colored paper matches the old one, which meantime may have been lost or changed color by fading or otherwise, the new sample is placed on the white

ground so as to appear in the right half of the field, and any difference from the old sample will be at once apparent.

There is an aperture in the case at the left of the eye slit, through which the three color slits can be seen directly, and watched while opening and closing to see that the movement is smooth and that they close exactly alike at top and bottom, which they will if the slit slides are in place on their runners and the slit fingers have not been bent. The best way to test the accuracy of their setting for zero is to turn two of the pointers past the zero point (by lifting over the stop) to secure an absolute cut off of light from the respective slits, then turn the remaining screw while looking through the eye slit. The field should just go black when the pointer is turned down to zero, and then show a trace of light when turned up two divisions on the scale. If it does not, hold the pointer to zero and adjust by turning (with a screw driver) the inside pin screw. Test the other two slit adjustments in the same way. The adjustment may stand true all day, but temperature changes are liable to affect it. The image of the central slit must also fall exactly in the middle of the eyepiece slit. This can be determined by looking at the eye slit through a small magnifier, provided for this purpose, and if readjustment is necessary it is effected by a slight lateral displacement of the eyepiece slit.

A point which may be noted about the reading is that the difference between the highest scale number and 100 represents black, and the difference between the lowest scale number and zero represents white. Thus the reading R 50, G 20, B 60, indicates 40 per cent. black and 20 per cent. white, degrading a hue which is three parts of red to four of blue. While considerations of this nature are interesting, and have their uses, the simple numerical expression R 50, G 20, B 60, serves every purpose for record and reproduction.

While the description which I have given will doubtless serve to make the operation of the new color meter sufficiently clear, the subject is far from being exhausted, and I cannot close without discussing briefly some other pertinent matters.

In the first place, in order to make measurements having a high degree of precision, the spectrum colors with which the measurements are made must be taken from the right places in the spectrum, and in sufficiently narrow, isolated bands. This

is determined by the focal length of the collimating lens, the dispersion of the grating, the spacing of the slits, the width of the color slits, and the width of the eye slit. In this instrument, the spectra at the plane of the eye slit are nearly one cm. long, and so pure that the Fraunhofer D, E, and F lines look sharp under a two and a-half inch magnifying glass when the R slit is one-third open, and the G and B slits half open. Practically, therefore, the degree of purity and isolation of the spectrum colors depend chiefly upon the width of the eye slit, which determines how wide bands of the substantially pure spectra shall enter the pupil of the eye. The eye slit is 1 m.m. wide, and therefore pretty sharply defined bands of spectrum color are utilized, each not much more than one-tenth as wide as the entire spectrum. In determining a standard for this adjustment, two factors had to be taken into account, namely, aperture of field and luminosity of image,—the first on account of the yellow spot in the retina, and the second because the illumination may be either too weak or too intense to favor a high degree of accuracy in making observations. The shorter the focal length of the field lens, the larger angle the field subtends to the eye, and the smaller the spectra projected at the eye slit. The smaller the spectra at the eye slit, the narrower that slit must be made to secure a given degree of purity of spectrum hue. The narrower the eye slit, the feebler the illumination. If the field subtends too small an angle to the eye, too much of the image falls upon the yellow spot of the retina, which, while it is the best part of the eye for distinct vision, is comparatively insensitive to peacock blue spectrum rays, and makes a high degree of accuracy of measurement out of the question, especially as this yellow spot varies greatly in size and depth of color in different individuals. The image on the retina must be large enough to cover a considerable area outside the yellow spot, and this is first of all provided for. If the illumination is too feeble, the sense of color is not sufficiently excited, as witness colored objects seen by moonlight. If the illumination is too intense, it destroys the sensitiveness of the retina; and this is so far true that Sir William Abney requires a rest of the eyes in darkness for some minutes before making eye tests with his color patch apparatus. With six-inch focus

field lens, $1\frac{1}{2}$ in. in diameter, and 1 m.m. eye slit, the field is large and well illuminated.

In short, to meet practical requirements, certain compromises have to be made; and if they are made intelligently, with a full comprehension of the nature and relative importance of all the factors involved, the result will be, and in this case is believed to be, worthy of acceptance as a permanent standard.

The analysis colors must be just pure enough so that the purest reds, greens and blues that are met with in the arts and industries can be perfectly matched,—the deepest ruby, green and cobalt glasses, and deep shades of the most brilliant coal tar dyes, particularly the violet purples. There was no difficulty about the purest blues and greens that could be obtained, but in order to match certain reds and aniline violets I had to take my red slit further towards the end of the spectrum than would be necessary with a narrower eye slit, and then to make the red slit wider than the others in order to make a white of the mixture. The practical efficiency of the combination finally adopted was proved by careful tests with coal tar colors in combinations adjusted to show narrow transmission bands in the spectroscope, but not until the slit fingers had been very accurately fitted and the inside of the case specially lined and diaphragmed to prevent any scattered light from reaching the grating.

The theoretically higher degree of accuracy which might be attained by sacrificing all considerations of commercial expediency would therefore never be detected in using the instrument for those purposes for which it is designed, and for which it is certainly far more accurate than any device which involves the multiplication of reflecting surfaces to secure increased absorption. In this connection, it may be pointed out that two pieces of pot colored glass, the sum of whose thickness is two m.m., have not the same value as one piece two m.m. thick, and the diffraction color meter will measure the difference by several degrees of scale.

Admitting that one of these instruments is calculated to meet every practical requirement, there remains only the question whether exact duplicates of it can be made with certainty, so that there shall be no doubt about the readings of different instruments being alike. The gratings are all casts

from one original, exactly alike, permanent and unchangeable. The slits are ruled on a standard make of dividing engine, with definite settings and feeds, and are also exactly alike, permanent and unchangeable. Other parts are made to gauge, and the only thing that would be likely to introduce any error is want of uniformity in the focal length of the lenses used. They are made to order and supposed to be alike; if they are not, and the error is small, it suffices to see that the extension of the eyepiece is right to make the image of the slit and spectra focus exactly on the plane of the eye slit, and wave lengths 43, 53 and 66 from the color slits will then superpose in the middle of this slit, as required.

It is necessary to state that because there is a perceptible change of luminosity of each analysis color in passing from one edge of the eye slit to the other, the field must be viewed with the eye slit crossing the pupil of the eye centrally. This is insured by bringing the eye back to a point where the right and left edges of the field are slightly and equally cut off from view by the edges of the slit.

There is still one other point which I must touch upon, though very briefly, and that is the relative facility and accuracy with which different individuals may be expected to make color measurements with the instrument. Much will, of course, depend upon the practice, but after a few hours' practice pretty accurate measurements should be made and verified by repetition in from one to five minutes, provided that the operator has normal color vision. Color blindness, even in small degree, is fatal to accuracy. Even the normal eye is very much more sensitive to percentage changes in some hues than others, and it is well to know that small errors are apt to occur by reason of such known facts as that two per cent. of any color may be added to a perfectly neutral white without being recognized as color. Such limitations are introduced by the eye, and may not be charged up against the color meter.

The purest colors can be matched the quickest. For instance, a very deep and pure red, obtained by combining screens of aniline violet and yellow, is matched by closing the blue and green slits completely, and then moving the "red" pointer down the scale until the luminosities match. It can be done with considerable precision in four or five seconds. On

the other hand, if the red is of a slightly orange hue and at the same time not of very high luminosity, it is difficult to get exactly the right minute proportion of green and make both hue and luminosity match. Pale shades of purple reds are rather difficult, balancing the red and blue with just the right amount of green and in the right quantities to match both hue and luminosity. All kinds of greens, blues and yellows, strong or weak, are comparatively easy to match.

Something should be said about standard white backgrounds, but I have not yet done much with that part of the subject, and will now merely state that for transparent objects nothing could be better than a sky background when it is raining or foggy.

In conclusion, I would point out that the same instrument, with sunlight or electric arc focussed exactly on the eye slit, becomes a perfect projection color patch apparatus, much more convenient than anything heretofore used for that purpose. I have, however, devised a modification still better adapted for that particular purpose, with increased illumination by use of both right and left spectra, and this device will be the subject of another paper.

STRAWBOARD WASTE.

A recent publication of the United States Geological Survey that should have wide circulation in the States where strawboard is manufactured is a paper entitled "The Prevention of Stream Pollution by Strawboard Waste." The author is Mr. Earle Bernard Phelps.

The total waste discharge into the streams in 1900 amounted to 10,239,-710,000 gallons of liquor, containing 184,777,382 pounds of straw and mineral matter and 77,191,660 pounds of lime. This enormous waste was discharged by fifty-nine plants of various sizes, but as most of these mills are along small streams the resultant pollution is very apparent.

Experiments conducted in the Sanitary Research Laboratory and Sewage Experiment Station of the Massachusetts Institute of Technology show that 93 per cent. of the suspended organic solids and 98 per cent. of the total suspended matter determined as turbidity can be removed, after a short period of sedimentation, by filtration of the liquor through sand, without coagulants. The present method, that of sedimentation in large fields, is pronounced unsatisfactory, expensive, and based on a wrong principle. The sludge resulting from the sedimentation tanks is declared innocuous after being pressed. It is said to make good soil and to have some value as a fertilizer.

Section of Physics and Chemistry.

(Stated meeting held Thursday, October 11, 1906.)

A Resume' of the Literature of the N Rays, the N_1 Rays, the Physiological Rays and the Heavy Emission, With a Bibliography.*

George Flowers Stradling, Ph.D.

This paper aims to give a statement of the properties claimed to belong to the N rays, the N_1 rays, the physiological rays and the heavy emission, with a history of the investigations and of the decline of belief in the existence of these rays.

In brief the N rays were believed to increase the brightness of an already luminous phosphorescent calcium sulphide screen on which they fell, while on the other hand the N_1 rays lessened its brightness. Barring certain differences of penetrating power, the physiological rays seemed about the same as the N rays. The heavy emission was held to consist of streams of matter ejected from objects, such as metals and liquids, and to be acted on by the attraction of the earth. It, too, made the phosphorescent screen brighten. Still another type of rays, the N_2 rays, has been discussed by a single writer, Breydel.[60]*

Blondlot discovered the N rays, the N_1 rays and the heavy emission; Charpentier discovered the physiological rays. All were first observed in Nancy. It is from the name of this university town that the letter N is taken as a designation.

In the account now to follow results will be quoted at the valuation of the investigators. No attempt will be made to avoid contradiction of properties claimed. Because of their similarity it will be impossible always to distinguish sharply between the N rays and the physiological rays.

*Numerals above the line refer to the numbers of papers in the bibliography at the end of this article.

In 1902 (Paris, C.—R. Acad, sci., 134, p. 1559, June 30, 1902,) Blondlot published his observation that the brightness of a very small spark increases when X rays fall upon the spark gap. During the latter half of the same year he determined, as he thought, the speed of the X rays, reaching the conclusion that they are propagated in different media with the speed of light in air. His method depended upon noting changes in the brightness of a small spark, and was therefore somewhat subjective in nature. In pursuance of this line of work, there appeared on February 2, 1902, a paper by him, with the title, "Sur la polarisation des rayons X."[26] It marks the beginning of N ray literature, though it contains no word about N rays.

The previous endeavors to polarize the X rays had failed. Blondlot proposed to himself to determine whether they are already polarized when emitted. He saw that the kathode ray and the resulting X ray fix a plane. Either in this plane or else perpendicular to it the X rays might have special properties. In his search for lack of symmetry he tried the small spark of his previous investigations in various positions, and was led to conclude that "The little spark plays the part of analyzer. The beam of X rays has the same symmetry as a beam of polarized light." Moreover quartz and sugar were found to rotate the plane of polarization both of light and of the X rays in the same direction.

Three weeks later he states that polarized light acts on the spark just as the X rays do. (Paris, C.—R. Acad. sci. 136, p. 487, Feb. 23, 1903). A month later he reverts to the X rays, and finds that, by transmitting them through a sheet of mica, elliptical polarization is produced, the tiny spark still serving as analyzer. This means double refraction in the mica, and *a fortiori* simple refraction. A quartz prism was found to deviate the beam, and a lens of the same substance to give a sharply defined image of the anti-kathode from which the rays came. Polished glass reflected the beam regularly, while ground glass diffused it. These facts of reflection and refraction proved that the rays in question were not X rays. Blondlot therefore felt justified in calling this paper "Sur une nouvelle espèce de lumière."[27]

The index of refraction for quartz was calculated to be about 2. Rubens, for his very long wave-lengths, had found the value 2.18. The nearness of these two quantities suggested to Blondlot that his new rays might also be emitted from the Welsbach mantle,

which served Rubens as a source of radiation. In his first paper in May, 1903, he announces that this is in fact the case.[28] Behind a quartz lens four foci were found, corresponding to these indices of refraction 2.93, 2.62, 2.44 and 2.29. The rays acting for an hour on a photographic plate produced no effect, but a difference was got between the two effects obtained by letting the light of a small spark act on the plate once with the rays falling on the spark gap and again without them.

A study of transmission through many substances was made.

Later in the same month Blondlot[29] found still other sources of his rays in a luminous gas flame and in a sheet of iron or of silver heated by a flame. A heated sheet of polished silver gives off plane polarized rays. A covering of soot increases the emission but destroys the polarization. In this paper their discoverer formally designates the rays by the letter *n*. This was subsequently changed to N.

Thus far the only known effect of the new rays was the brightening of a small spark. Blondlot now found that they made a small blue gas flame more luminous and white. He recommends examining the blurred image of the flame cast on a sheet of ground glass. A third effect was discovered in the brightening of an already luminous calcium sulphide screen on which the N rays fall. This became the favorite means of observation. If the screed is not already luminous, the N rays do not make it so.

Blondlot ventures the opinion that his rays lie in wave-length between the shortest electromagnetic waves and the longest of Rubens.

In the following month, June, 1903, the N rays formed the subject of editorials in the Electrical World and Engineer[239] and in the Electrician of London.[243] The latter says: "It is very strange that other physicists have not taken up this pregnant subject. Their lethargy contrasts curiously with the rush made for the Roentgen rays in 1896." But three days afterwards another physicist, Sagnac,[138] did take up the subject, though from the theoretical and not from the experimental side. He discussed Blondlot's observation of four foci behind a quartz lens and concluded that three of them are merely maxima due to diffraction of waves of length 0.2 mm. It is to be noted that this, the first criticism of Blondlot's results, is from the pen of a fellow-

countryman. Sagnac, however, utters no doubt concerning the actual existence of the rays he discusses.

In the issue of Comptes Rendus containing Sagnac's article, Blondlot[30] announces that there are N rays in sun-light. They appear to have the same properties as those from other sources.

In July, 1903, but one paper on the N rays appeared. In this Blondlot[31] states that when platinum is heated to a dark red by the electric current or by a flame, it is made brighter by focussing upon it a beam of N rays. Sensitive tests showed no rise of temperature caused by these rays. This was confirmed by Rubens also. Hot platinum was found to transmit the rays.

At the *Versammlung deutscher Naturforscher und Ärzte* in Cassel in Sept., 1903,[195] Kaufmann of Bonn, Donath of Berlin, Classen of Hamburg, with Rubens and Drude, all acknowledged failure in their endeavors to repeat Blondlot's experiments. The testimony of Rubens was especially significant because he had received from Blondlot advice as to experimental arrangements.

November, 1903.—After a long silence Blondlot[32] resumed the publication of his investigations. A band of white paper, faintly illuminated, was found to appear brighter and to have sharper outlines when a beam of N rays fell upon it. When an illuminated slit was seen reflected from a polished knitting needle, upon which N rays fell, the image darkened and turned reddish when the rays were cut off. A bronze mirror acted in the same way. When N rays fall normally upon a polished quartz surface they have no influence upon light reflected at any angle of incidence from the same surface. N rays coming through quartz affect the image formed by reflection at the surface through which they emerge.

There seems to be no action of the N rays on refracted light. The Nernst lamp without a glass globe is given as a source of strong N rays.

A week later Blondlot[33] announced that many substances after having been exposed to N rays will themselves emit this radiation for some time. This storage effect resides in the mass and not merely on the surface.

In his last paper for this month[34] he states that N rays reaching the eye from any direction increase the brightness and sharpness of outline of feebly illuminated surfaces. Since water had been found to be opaque to N rays it excited his surprise that they

could traverse the liquids of the eye. Since these liquids contain dissolved salts the reason became clear, when experiment showed that the addition of a small quantity of salt to water caused it to transmit the rays. Salt water also stores the rays. Similarly the eye of a steer proved transparent to them and showed the storage effect.

December, 1903.—Acting upon a suggestion taken from the researches of Charpentier, as yet unpublished, Blondlot[36] made the discovery that wood, glass, caoutchouc, etc., while compressed emit N rays. If an observer, looking at a barely visible white clock face in a darkened room, bends a cane before his eyes, he sees the dial become white, only to darken again when the cane is released. Such observations led to trying whether bodies in a permanent state of molecular strain do not also send out the rays. Prince Rupert drops, tempered steel, hammered brass, melted sulphur with crystalline structure, all proved to be spontaneous and permanent sources of the emission. A file or a pocket knife caused the calcium sulphide screen to light up. A steel tool was active when tempered, but was without effect when the temper was removed. A knife from a grave of the time of the Merovingians emitted the rays even after a dozen centuries of existence. Permanently deforming metals causes an emission of the N rays for a few minutes at most. Torsion produces the same effect as compression.

On Dec. 14, 1903, the first paper by Augustin Charpentier[64] appeared. He has published more papers than Blondlot himself upon the subject under consideration. He was the discoverer of the physiological rays. The La Craze prize in physiology was awarded to him in 1901 by the Academy of Sciences in Paris, to the Comptes Rendus of which body he contributed more than fifty papers.

In this paper Charpentier[64] announces the startling discovery that a barium platino-cyanide screen, made luminous by radium, grows brighter when brought near to the human body, especially to a nerve or nerve center in activity or to a contracted muscle. The course of a superficial nerve could be traced by means of the screen, and the outlines of the heart were obtained. Aluminium, paper and glass transmitted the rays. They are reflected and refracted, real foci being formed by a glass lens. It seemed that a

new method for physiological examination had been brought to light.

In a paper two weeks later Charpentier[65] claims that hares and frogs emit his rays. The possibility of explaining the effect on the screen by the action of heat was excluded in the case of the frog whose temperature was below that of the screen. In another trial the screen was heated above the temperature of the body and yet the brightening occurred.

Tendons stretched by the muscles gave no effect. Pressing a nerve increases its effect on the screen. Nerves, and especially nerve centers, are better radiators than muscles.

N rays in sun light cause a glow worm and phosphorescent bacilli to grow brighter. When a person speaks a screen held near the center of articulate language in the brain lights up. Mental effort was thought to affect the screen.

In a paper in Paris, C.—R. soc. biol., for Christmas, Charpentier[83] recounts about the same results as those given previously in his first paper of this month and in his second in Paris, C.—R. Acad. sci. This marks the appearance of the physiological rays in this periodical, in which altogether about a score of papers bearing on the subject appeared. Most of them are practically the same in content as other papers by the same authors in Paris, C.—R. Acad. sci.

On Dec. 28, 1903, Paul Audollent [227] submitted to the Academy of Sciences a claim with respect to the emission of radiation from most natural bodies of priority against Charpentier. Within a short time a similar claim was made by Köhler, Baraduc,[228] Darget,[230] Galtier,[233] Huter,[234] and others. The matter was referred to D'Arsonval[226] who reported in April, 1904, that Charpentier had not claimed to originate the idea that besides heat radiation there are other radiations from the body. The idea is in fact centuries old as is proved by the belief in the pictures of mystic painters, the fluid of magnetizers and the od of Reichenbach. Most of the claimants got their results by photography, none by the phosphorescent screen.

Dubois[231] claimed Charpentier's results to be confirmatory of results which he obtained as early as 1885, viz,—that living organisms can emit radiation capable of producing fluorescence.

S. G. Brown[146] states that he independently discovered phosphorescent zinc sulphide to brighten in the vicinity of the human

body. At first he thought it due to an unknown radiation, but further examination convinced him that heat was the cause.

At this time begins that series of papers recording failure to obtain Blondlot's results, suggesting sources of error and indicating explanations of the phenomena claimed to be observed that did not cease until the entire group of rays was discredited.

Zahn[194] tried in vain to detect the effect of the N rays by measuring the resistance of a selenium cell illuminated first by a small flame alone, and then by the flame while N rays were falling upon it. Nor could he see any difference in the flame under the two conditions.

Lummer[172] called attention to the circumstances of Blondlot's experiments,—small faintly luminous surfaces regarded in the dark,—as exactly such as would favor a shifting of the retinal image from a part of that organ where it fell upon cones to another part containing rods, with resulting change of color and luminosity, and of sharpness of outline. He records Ruben's failure to see any change of brightness.

January, 1904.—This month saw the corps of investigators in the field of the new rays increased by the addition of E. Meyer,[124] who claimed to find N rays emitted by the flowers, leaves and sprouts of plants. The effect was lessened when chloroform vapor acted on the plant. A second new worker was Macé de Lepinay[121] who announced that solids in sonorous vibration and even the air in vibration emit rays that brighten the phosphorescent screen. Lambert[116] was a third. He found N rays to appear in several cases of artificial digestion. Above each of two photographic plates an equal patch of CaS was placed. Over one was put a tube in which artificial digestion was in progress. When developed the two images were not of the same intensity.

Blondlot[37] published a memoir on the dispersion of the N rays and on their wave-lengths. A prism of aluminium gave eight refracted rays, detected by the CaS screen, of indices ranging from 1.04 to 1.85. Seven conjugate foci were found behind an aluminium lens. These last gave indices agreeing well with those obtained by using the prism.

To get the wave-lengths each of the eight refracted rays was made to fall in turn on a refraction grating and a system of fringes obtained as in the case of light. Thus wave-lengths were found ranging from .00815 μ to .0176 μ. These values were

confirmed by a study of the Newton's rings in N rays. Contrary to what holds for light waves the wave-lengths and the indices of refraction of N rays increase together. It will be noticed that the small value of the wave-lengths given in this paper is in decided contrast to Blondlot's as well as to Sagnac's[138] previous estimate.

Blondlot's method here has been severely criticized by the only two papers of importance coming from the American continent. Schenck[184] shows that some of the eight beams found behind the prism must have overlapped, and that the diffraction fringes were not to be believed in as they must have been lacking in definition. He also sharply criticizes the Newton's rings experiment.

Wood[193] noted that a beam of N rays 2 or 3 mm. wide was said to give after refraction a band only a part of a millimeter in width. When he removed the prism, it made no difference in the location of the refracted rays by the uninformed observer. When the prism was placed by Wood with its refracting edges now to one side, now to the other, in none of three trials was the observer correct in determining its position from the direction of the refracted rays.

Charpentier[66,84] resumes his work by indicating certain differences between the varieties of physiological radiation and the N rays. Neither lead nor water stops the former, while aluminium, transparent to the N rays, partly stops rays from the brain. It is however partly transparent to rays from the heart, the diaphragm and other muscles, though not to radiation from nerves. Pressure has a greater effect upon nerves than upon muscles in making the emission greater. A third difference between muscles and nerves is that the latter produce a greater effect on a warmed phosphorescent screen.

Later in the month[67] he brought out a new method of observing his rays. A small copper plate is fixed at the end of a wire of the same metal, 90 cm. long. At the other end is the phosphorescent screen. When the human body is opposite the plate the screen lights up, indicating transmission of the radiation through the wire. N rays are transmitted in the same way. This contrivance was admirably suited for investigation.

In a paper of the same date in another periodical Charpentier[98] takes up the effect of mental effort. An observer looks at a screen placed in front of the forehead of a person seated. The

latter changes his mind from rest to activity or *vice versa* without the observer's knowing it. At each change a variation of the brightness of the screen follows. Change from thought to repose causes dulling; the reverse change, brightening.

Bohn[58] uses the N rays to explain certain actions of a nereid. When the worm is in salt water, it swims while in the light but walks in the shadow. In fresh water the sensibility to light is less. This may be connected with fresh water being less transparent to the N rays than is salt water.

This month it is Swinton[186] who reports failure. He attributes the results which others obtained to physiological processes not operative in all persons.

February, 1904.—In the course of the month Blondlot published three papers. In the first [38] he describes how he registered photographically the effect of his rays in making a small spark brighter. This will be discussed at length later in this paper. In the second[39] he tells of the discovery in the radiation from a Nernst lamp of a new kind of rays, designated the N_1 rays, which lessen the brightness of a luminous phosphorescent screen. He determined the wave-lengths of three kinds of these rays by refraction through an aluminum prism and subsequent diffraction. Stretched bodies emit the N_1 rays. They are stored as are the N rays. In his third paper[40] he states that N rays increase the emission of light at right angles to a CaS screen, but lessen the tangential emission, while N_1 rays act in the opposite manner for both angles. Sonorous vibrations, the magnetic field, and an electro-motive force act as do the N rays.

Charpentier contributed five papers this month. He states[70] that the N rays increase the sensitives of vision, smell, taste and hearing.

Glass and wood were found to conduct the N rays. Transmission was effected through a wire 10.5 in. long in 13 secs. CaS is a source of N rays, when phosphorescing.[69] N rays acting upon certain portions of the skull caused an increase of brightness or of sharpness of outline. When N rays fall upon a part of the spinal column the pupil dilates.[68] The remaining two papers are of about the same content as those already quoted.[85,86]

Charpentier in conjunction with E. Meyer[100] studied the effect of inhibition upon the emission of the physiological rays.

E. Meyer[125,127] found that, even when plants are kept in the dark, they emit N rays.

The list of papers for this month shows several new names.

Bagard[1] determined the rotation of the plane of polarization of all eight wave-length of the N rays while traversing aluminium and CS_2 in a magnetic field. As was to be expected from the smallness of the wave-lengths, the effect was much larger than with light. All varieties of the N rays were completely polarized by reflection from glass.

Ballet[3] contributes a study of the emission of N rays in certain pathological cases. In paralysis there is a diminution of emission in some cases, while the opposite result was found in others. After death muscles cease to act on the screen, while nerves continue to exert their effect, gray matter being more active than white. He says he took care to avoid the effects of speaking, temperature, change of accommodation and auto-suggestion.

Bichat, dean of the Faculty of Sciences in the University of Nancy, presented three papers. He explains the transmission of N rays through a wire as due to successive internal reflections.[18] This effect he regards as similar to the passage of a beam of light along a curved jet of water.

He formed the spectrum of the N rays and then examined the absorption of each of the eight resulting rays by glass and several metals. Silver was found to be transparent to all, while palladium, nickel and iridium were opaque to all. Lead, copper, zinc, gold and glass transmit some rays and absorb others.[19] Wires of the metals were found to transmit only those rays for which they were transparent.

Liquified gases were found to emit N rays.[20] Jégou[114] detected the emission of N rays by a wire conveying an electric current. When the circuit of a Leclanché cell was closed, the liquid stored the rays and became an energetic source.

Richet[136] studied the effect of the rays emitted by phosphorescent calcium sulphide upon lactic fermentation. There seemed to be in reality an effect, but the investigator noted that other causes as well as N rays were possible.

Gutton[160,161,162,163,165] examined the effect of magnetic fields upon the phosphorescent screen. A uniform field of constant intensity had no effect, but, if the intensity changed with time or if

the field was not uniform, the screen brightened. Any action tending to set up in the screen an induced E. M. F. made it brighter. He claims to have detected the magnetic effect of convection currents by the screen. A magnet encased in lead to cut off the N rays caused faintly illuminated surfaces to appear brighter, when it was brought near the eye.

Walsham and Miller[139] in a letter to the Lancet confirm Charpentier's chief results as to rays from muscles and nerves. Moreover they got photographic results with the screen which they interpreted as showing the brightening effect. This letter is followed by a brief editorial confirmation of their results, which indeed had been expressed in the issue of the Lancet for the preceding week.[251,252]

Burke[147] reports his failure to get N ray effects. Swinton[187] now finds it easy to get some effects, so easy in fact that he is led to attribute the result to heat. Nagel[175] reported to the Berlin Ophthalmological Society his complete failure in endeavoring to repeat the experiments of Blondlot and Charpentier.

March, 1904.—Lambert resumes his work on the production of N rays by digestive ferments.[118] He also examines the N ray activity of an electric cell after the passage of the current and finds it due to chemical processes in the cell. Osmotic processes and diffusion make the screen to grow brighter.[117]

Macé de Lepinay[122] states that a CaS screen viewed normally grows brighter when sonorous vibrations are produced, while to one viewing it tangentially it appears darker. He thus confirms both his own previous observation and that of Blondlot.[40,121] This was his last contribution to the subject. Within a few months his death occurred.

Bagard[2] measured the rotation of the plane of polarization by several active substances, cane sugar, tartaric acid, etc., and found rotation in both directions to occur.

A comparison of the effects of heat and of the N rays upon the phosphorescent screen was made by Blondlot.[41]

No less than seven papers are this month due to Charpentier. He finds additional sources of rays in compressed caoutchouc, ice near zero, iodide of silver, bent ivory and celluloid, in the biceps muscle striving in vain to contract.[72,88,89] He notes a difference in the effect of an N ray source according to its condition of rest or motion. The N_1 rays diminish the sensations of

sight, hearing, smell and taste. He verified the effect of the N rays in rendering the sense of hearing more acute.[71,87,88]

When the screen rests on the fingers it lights up upon the application of an N ray source to the hand or arm or to the surface of the body. If the screen is near the heart it grows brighter when the source is applied to the pneumogastric nerve in the neck. Smell and vision are helped when the source acts on the hand. The effects of the N_1 rays are transmitted in about the same way. It appears that the nerves transmit the rays as wires do.[73,89]

The alkaloids and chloral emit considerable quantities of N rays.[74,90] Their action on the phosphorescent screen is re-enforced by the presence of some other source of N rays. In this case the joint action is greater than the sum of the two separate actions. When a screen was employed consisting of a patch of CaS upon a thicker layer of alkaloid it was found that different parts of the body produced varying degrees of brightness in the screen, and that the effect of any part of the body depended upon the particular alkaloid used. That part of the body producing a maximum effect upon an alkaloid screen is the one upon which the alkaloid produces its toxic effect. For example a digitalin screen is especially bright near the heart.

Charpentier and E. Meyer extend their previous study of inhibition, finding N_1 rays also to be emitted.[101]

According to Ballet[4] the N rays can be used for diagnosis. A CS_2 screen is less bright against a sick muscle than against a well one. By the same means one kind of paralysis can be distinguished from another. He found the rays to be given off by the bodies of dogs the day after death.

The paper bearing the names of Ballet and Delherm[5] is not very different from Ballet's paper of Feb. 22, 1904.[3]

In 1900 de Hemptinne had looked for an effect of a homogeneous magnetic field upon CaS and other phosphorescing substances, but to no purpose. After the publication of Gutton's work[160,161,162,163,165] he tried the effect of non-homogeneous fields on calcium sulphide and again found no difference.[168] He modestly attributes his failure to a subjective effect, to a lack of sensitiveness of his eyes or to some peculiarity of his specimen of Ca S.

Hooker[112] wrote to the Lancet confirming the effect of vegetation in making the screen brighter.

On the other side Swinton contributes two more letters[137,138] reiterating his lack of success, and emphasizing a possible explanation by heat effects. Like de Hemptinne he fails to get Gutton's results with a magnetic field. Walsham and Miller reply to him.[140]

In answer to the various English criticisms Blondlot addressed a letter to the Electrician, London.[51] He relates that Mascart, President of the Academy of Sciences, and Cailletet came to Nancy to see his experiments. "They saw and repeated them themselves, they determined themselves the deviations of the N rays, by a prism of aluminium, and the focussing of them by an aluminium lens, they observed the fringes produced by gratings, Newton's rings, etc. They did not show the least doubt in the existence of the N rays. M. Mascart took away with him a double photograph taken in his presence or rather with his coöperation."

"A few days later I was visited by M. J. Becquerel who observed without difficulty the N rays phenomena, and who proposed in parting to follow up the study of some of them."

"I may add that I have not published one single experiment which had not been repeated by several colleagues and also by persons not acquainted with scientific research work. I have encountered but three or four persons—out of a great number—who were not able to observe the phenomena."

Rudge reported his inability to repeat Blondlot's experiments.[182] In a communication already referred to Schenck[184] of McGill University says that he obtained no certain results with the CaS screen. Differences of brightness were noticed which might have been due to

1. Decay of phosphorescence.
2. Obliquity of angle of vision.
3. Increase of sensitiveness of eye in the dark.
4. Heat effect.

It was during this month of March, 1904, that apparatus for N ray experiments was put upon the market. The manufacturer was Leslie Miller, London. He describes his apparatus in a letter to the Electrician.[133] It consisted of a hard rubber rod carrying at one end a circular box of the same material, 4 cm. in diameter. The front of this was closed by a strong plano-convex

lens with the convex side outward. On the back of the lens was a patch of Ca S about .35 cm. in diameter. In contact with this was a brass plate to which was attached a flexible wire passing out through the back of the box and ending in a small disc of metal. Upon this the N rays were supposed to fall and then to pass along the wire to the phosphorescent substance.

Several sets of this apparatus were imported into America. The advertisement in Nature spoke as follows of this apparatus: "By means of the above instrument it is guaranteed that the chief N-ray (possibly 'heat') effect, discovered by A. Charpentier, can be clearly demonstrated, including transmission by wire. The objective existence of the rays can be proved by placing the instrument on a book of any thickness, in a room so dark that an operator's arm cannot possibly be seen and asking an observer to say when the wrist is brought beneath the book." "In box with transmission wire, magnesium ribbon, etc., price £1, 1, 0."

April, 1904.—This month falls far behind all the previous months of the year in the production of N ray literature.

Charpentier[75,90] announces the discovery that, if the extract of an organ of the body be interposed between a phosphorescent screen and the organ itself, the screen is brighter than in the absence of the extract. This, he claims, will make it possible to adopt a special screen to the study of each organ.

According to Colson[102] if a Ca S screen is put near a test tube containing $Zn\ S\ O_4$ solution into which K O H solution is poured, the screen grows less luminous, indicating N_1 rays. However, if the tube contains K O H solution into which $Zn\ S\ O_4$ solution is poured, no change of the screen follows. Blondlot verified these observations. The difference of results is attributed to the formation of a basic sulphate in the first arrangement.

Still another member of the faculty of the University of Nancy joins himself to the corps of experimenters in the field of the Blondlot rays. Julien Meyer[129] finds stretched glass or copper and vacuum tubes to be sources of N_1 rays. They have greater penetrating power than N rays. They are stored, refracted and diffracted.

Munro[134a] wrote to the Lancet to suggest the study of the emission of N and N_1 rays from the body as a test of death. The accompanying editorial note indicates doubt.[253] Miller,[134] on the contrary, is confident that he can tell, by means of the

phosphorescent screen, when a man brings up his hand and stretches his muscles behind a cardboard screen in a dark room.

McKendrick and Colquhoun[173] make public their failure in striving to repeat Blondlot's experiments. They suggest heat, certain physiological actions and an attitude of expectancy as factors in the results obtained.

Hertzian waves, according to Gutton,[164] cause a Ca S screen to brighten. By this means he verified polarization and reflection. Similar effects were got with feebly illuminated ground glass.

May, 1904.—In this month the studies of Charpentier are continued by seven papers. He used the N rays to measure the wave-length of oscillations set up in the nerve of a frog by brief electrical excitation. By this method even overtones were found.[76,91] The conclusion was drawn that the vibrations are longitudinal.[77,92] The dessicated bodies of frogs continue to emit N rays for several months after death.[79]

A screen consisting of an odorous substance with Ca S was found to be especially sensitive to radiation from the olfactory centers, and a small incandescent lamp covered with black paper with a patch of the phosphorescent sulphide responded to rays from the visual centers.[78,92]

Chrome alum, according to Colson,[103] dissolving in cold water produces N rays; but dissolving rapidly in boiling water it develops N_1 rays of such strength as almost to darken the screen. Those chemical actions which cause the Blondlot rays are always attended by physical effects such as contraction, cooling, etc.

Lambert and E. Meyer[119] conclude that N rays diminish the protoplasmic activity of seed.

In the same issue of the Paris, C.—R. Acad. sci. two new workers in the N ray field appeared, André Broca[61] and Jean Becquerel,[7] the son of Henri Becquerel and a scientist of the fourth generation in his illustrious family.

The former[61] gives the details of construction of a sensitive Ca S screen, whose brightness is constantly changing when it is moved over the cranium. Along with Zimmern[63] he examined the emission from the spinal cord and obtained some apparently valuable information about the genito-spinal and vesico-spinal centers. In old people the nervous centers are less active than in the young, as judged by the effect on the screen.

By Becquerel[7] it was found that by anæsthetics such as chloro-

form and ether vapor and laughing gas the emission of N rays is suspended. After the removal of the vapor the rays are emitted once more. Previously E. Meyer[124] had observed that chloroform vapor caused plants to cease to emit N rays.

In Becquerel's next paper[8] he investigates the cause of the increased brightness of feebly illuminated surfaces under the influence of N rays. When a Ca S screen on which N rays fall is viewed through pure water it appears no brighter than without the rays. The substitution of salt water, however, causes the customary brightening to occur. This leads him to suggest that the N rays are the cause of no increase in the light emitted by the screen, but that having been absorbed by it they are again emitted and accompany the light rays to the eye whose sensitiveness they increase. The same may happen with dimly lighted paper or with a metal mirroring an object.

Blondlot[40] had found that a phosphorescent surface acted on by N rays looks brighter when the line of vision is normal to the surface, but duller when viewed tangentially. Becquerel[9] takes up this phenomenon and locates the cause in the normal emission of N rays and the tangential emission of N_1 rays, after the body has been exposed to N rays. After exposure to N_1 rays the kind of emission is reversed with respect to that just stated. He attributes the radiation of both N and N_1 rays to molecular movements existing in bodies in a state of deformation or of molecular transformation. Examining the wave-lengths determined by Blondlot he divides them into two series. The members of the first set are close multiples of 2.9 $\mu\mu$; for the second set 4.9 plays something of the same role.

After an interim of three months the name of Bichat[21] reappears at the head of a paper discussing fluctuations in a phosphorescent screen. These were found to be caused by many phenomena,—movements of air, convection currents, the presence of a tube of gas or of the human body. The fluctuations seem to him a delicate index of any kind of change. Chloroform vapor stops them.

In a second paper[22] he announces the results of his study of the storage of the Blondlot rays. The body under investigation was put in the path of the eight rays formed by dispersing the N rays by means of an aluminium prism. Platinium, silver and aluminium gave no secondary radiation, but copper, zinc and

glass did. The secondary radiation followed the law of Stokes in having a longer wave-length than the absorbed rays.

J. Meyer[130] found that the vapors of ether and chloroform diminish the emission of N_1 rays from stretched wire and an incandescent lamp bulb, though the vapors themselves emit the rays. It had already been noticed by E. Meyer[124] that chloroform lessened the emission from plants. With Broca Becquerel[17] examined the effects of anæsthetics on the emission of the Blondlot rays from the brain and spinal cord. At first the brain in anæsthesia emits strong N rays; later N_1 rays appear. The spinal cord shows less effect than the brain. These authors suggest the study of the rays in order to determine the danger point in the administration of anæsthetics and as an evidence of death.

It was the polarization of the N rays and their speed which were determined in his early work, Blondlot[50] now concludes, though he originally held the X rays to be concerned. "The N rays are entirely analogous to light, from which they differ only in their wave-length, which is much shorter."

On May 17, 1904, Hackett[111] read a paper in Dublin on the photometry of the N rays. Intervals of several weeks elapsed between series of his experiments and yet concordant results were obtained. As sources of N rays he used substances under strain, such as compressed wood or cork, tempered steel and unannealed glass. The increase of sharpness of outline of a diaphragm placed in front of a phosphorescent screen was the effect he employed in his experiments. When a source of N rays was brought up behind the screen the outlines of the diaphragm grew more distinct. When the source was removed, the diaphragm reverted to its former appearance. It was then shifted toward the observer until it appeared as it did when under the action of the N rays. From the distances in the two cases the percentage of increase of brightness produced by the N rays was calculated. His results were as follows,—unannealed glass, 10%; compressed cork, 9%; tuning-fork in vibration, 8%; silent tuning-fork, 3%. By this method the smallest change of brightness that could be detected was 3%.

In another method two similar phosphorescent screens with similar diaphragms wire adjusted with respect to the observer until the outlines of the two diaphragms appeared equally dim. Next one screen was subject to the N rays and the second screen

was moved nearer the eye until it again matched the first. "The observer may be ignorant of what screen is being influenced by the rays, but he will have no doubt which screen is the brighter." While confident of the effect of the N rays in making the screen brighter, Hackett failed to obtain many of the other effects.

(*To be Continued.*)

FUTURE SUPPLIES OF CONNELLSVILLE COKE.

The Connellsville *Courier* for February 7 says: The coking coal of the Connellsville and Lower Connellsville regions is practically all taken up. With the exception of a few odds and ends the Connellsville region is now all under operation, and these odds and ends are about to be cleaned up. The big purchases recently made in the Lower Connellsville region and the plans for their immediate development leave little available coal land in that region. At the present rate of consumption both these regions will be practically worked out within the next quarter of a century, if not sooner. Even the Latrobe or Upper Connellsville field and the Greensburg basin adjoining are now under active operation and will last scarcely as long as the two other fields.

The problem of a first-grade coke supply for the iron and steel trade would be serious if it were not for the fact that exhaustive tests have demonstrated that there is another big field of coking coal lying adjacent to the Lower Connellsville field, known to the trade as the Greene county field. It covers the greater portion of Greene county and extends westward almost to Wheeling. The same measures extend northward almost into Washington county for a limited distance and involve a small area of that county. Tests of the Greene county coal show it to be possessed of the same characteristics as the Lower Connellsville coal, the product of which is now classed with Connellsville coke. The Greene county field is in fact a continuation of the Lower Connellsville field westward, averaging 8 to 9 feet in thickness with a maximum thickness of 11 feet on Dunkard creek.

It is to the Greene county field that the iron and steel interests of the country are looking for their future supplies of furnace and foundry fuel. The H. C. Frick Coke Company has already purchased some 3,000 acres in Monongahela and Greene townships, and a company has taken up quite a body of coal on Muddy creek and is preparing to develop it at an early date. Several large concerns are negotiating for imperial acreages with a view of early operations. These negotiations are necessarily with J. G. Thompson, of Uniontown, who owns the larger coal area of no less than eleven townships of Greene county. His coal lies mainly east of Waynesburg and includes the larger portion of two townships west of that town. It all lies along or convenient to the proposed Uniontown and Wheeling Short Line. It is the main portion of the field and occupies largely what may be termed the basin.

GILA RIVER ALUM DEPOSITS.

Deposits of alum that present many unique characteristics occupy a small arid region in Grant County, New Mex., on both sides of the Gila River. These deposits, which have been studied and described by Mr. C. W. Hayes, of the United States Geological Survey, lie about twenty-seven miles due north of Silver City, and are at present accessible from that point by a wagon road, which reaches the Gila River at Lyons Hot Springs about six miles above, and thence follows the river down to the mouth of Alum Creek.

The alum deposits occupy a nearly circular depression below the general level of the volcanic plateau. The rocks of this topographic depression are andesitic volcanic breccias. They are the alum rock. The main mass of this alum rock occupies a nearly circular area, lying for the most part south of Gila River and west of Alum Creek. About the margins of this main mass are smaller areas occupied by the alum rock, the smallest being north of the river. Several small areas are found in the upper basin of Alum Creek. The relations of the alum rock to the adjacent basalt indicate clearly that the alum rock has broken through the basalt in the form of an igneous intrusion, probably with intense explosive violence. In every case where the contact was well exposed it was either vertical or at a high angle and the rock contained fragments of the basalt.

The most striking peculiarity of the alum rock is its extreme alteration. Careful search failed to reveal at any point within the Alum Creek basin a trace of the unaltered breccia for determination of its original character. Where exposed to leaching as in the upper parts of pinnacles and cliffs the rock is always porous, giving a hollow sound under the hammer. It is evident that a considerable part of its substance has been removed in solution.

Two forms of incrustations having entirely different chemical composition are common in association with the alum rock wherever the conditions are favorable for their accumulation. Upon the sides of the cliffs are extensive deposits of material evidently leached out of the adjacent rock and deposited from solution. These incrustations vary in thickness from a few inches to three or four feet. The outer surface has a fluted appearance resembling some stalactitic cave deposits. It is generally yellowish-white in color and is fairly hard with a porous cellular structure. Within this outer crust the material is much softer and ofter occurs as a perfectly white powder. This incrustation consists of the hydrate sulphate of aluminum, known as alunogen. The white powdery material is very pure and has practically the theoretical composition of alunogen, while the outer crust contains a slight amount of impurities and less than the theoretical amount of water.

The second form in incrustation is most abundant on the walls of the tunnels which have been driven into the alum rock. It consists of halotrichite, a silky fibrous mineral closely resembling asbestos in appearance. It has a very pale greenish color and a strongly astringent taste. The outer exposed surface of the incrustation has generally lost its fibrous structure, becoming compact and assuming a yellowish color. Although the incrustation may be several inches thick, the individual fibres are rarely

more than a third or a half of an inch in length, the crust being made up of successive layers of short crystals. Each layer probably represents the growth of a single season during which the supply of percolating water was relatively abundant. The layers of crystals are sometimes separated by a very thin film of the rock which has been split off by the growth of the subsequent layer of crystals.

The alunogen of the first incrustation is the sulphate of alumina and is free from iron, except as a minor impurity, the halotrichite of the second is the double sulphate of alumina and iron.

The value of the deposits will depend on the utilization of the soluble sulphates which they contain. The present surface accumulations of alunogen, while probably amounting to many hundreds or more probably thousands of tons, represent but an insignificant quantity compared with the sulphates still in the rock. Wherever observed the rock is highly porous, and the extent of its porosity represents the amount of material removed. In the higher and more exposed ledges the rock is thoroughly leached and will yield nothing more. At lower levels the rock still contains a part of its soluble constituents which are coming to the surface by the capillary circulation of surface waters.

Success in the development of this deposit will depend largely upon the skill with which the problem is handled. That there exists here an almost unlimited supply of aluminum sulphate appears, however, certain, and in view of the rapidly growing demand for this substance in the arts, and in sanitary engineering, and as a source of the metal, aluminum, there is little question that the supply will in time be fully utilized. The essentials for such utilization appear to be transportation facilities and chemical engineering skill. Dr. Hayes' report on this deposit will appear in the Survey's forthcoming annual "Contributions to Economic Geology, 1906."

Book Notices.

Report of the Commission Appointed to Investigate the Zinc Resources of British Columbia and the conditions affecting their exploitation. Mines Branch. Dept. of the Interior, Hon. Frank P. Oliver, M.P., Minister; Eugene Haanel, Ph.D., Supdt. of Mines. 399 pages, illustrations, plates, maps, 4to. Ottawa, Canada, Government, 1906.

The admirable scientific work which the Dominion of Canada has been doing in recent years is characterized by the broadest spirit in the selection of its agents and the greatest thoroughness in its work. Dr. Haanel was requested by the Minister of the Interior to outline the work necessary for the report, and Mr. W. R. Ingalls, Editor of the *Eng. & Min. Journ.*, of New York, was appointed chief of the staff, including Mr. P. Argall, M.E., of Denver, and Mr. A. C. Gardè, of British Columbia. The metallurgical investigation was undertaken by Mr. H. E. Wood, of Denver. The result is a valuable work of 399 pages, with a synopsis of the mining laws of British Columbia and a complete index.

The report of Mr. Argall on the zinc resources occupies 145 pages. This article gives the history, amount of production, character of ore,

market, valuation of ores, cost of smelting, value of the argentiferous blende, and wet processes of extraction in the United States; and for British Columbia the capacity, cost and methods of production, design of a zinc smelter, the works at Frank, Alberta, smelting rates on silver lead ore, preparation of zinc ores, magnetic separation, separators, plants in the Slocan, patent rights, electrostatic separation, flotation, railway transportation, electro-thermic zinc smelting, production, consumption and price; zinc mines of the Kootenays, Ainsworth Camp, the Slocan, E. Kootenay, rocks and ores of the Slocan, economic conditions, and milling in the Slocan.

Mr. Gardé reports on some mines of Ainsworth and the Slocan. Mr. Barlow reports on some undeveloped zinc deposits of British Columbia, including Vancouver Island, Texada Island, the Main Coast, and the interior of British Columbia.

Mr. Argall reports on methods for the concentration of zinc ores of British Columbia.

Henry Harris and Henry E. Wood report on the methods of assaying. Mr. Harris's flux for the silver assay was, litharge, 9 pts.; sod. bicarb., 3 pts.; borax glass, 1 pt., with a cover of salt. Three assay tons of this was used with 0.2 a. t. of the ore.

For Zn he mixed from 0.5 to 1 g. of ore with 10 cc. of water, afterwards adding 25 cc. of saturated solution of potassium chlorate in nitric acid. Evaporated and dehydrated. Added 5 g. sal ammoniac; 15 cc. ammonia, and 25 cc. water; boiled, filtered, diluted, neutralized with HCl, adding 10 cc. in excess. Titrated hot with standard sol. potas. ferro-cy., using uranium acetate as indicator.

The work is profusely illustrated by cuts, diagrams and half-tones, representing machinery, maps, scenery and ores.

It is a model of the manner of making such a report and will be a necessary reference book for the mining engineer and metallurgist.

F.

Sections.

Mining and Metallurgical Section.—Stated meeting held Thursday, May 9th, at 8 P. M. President G. H. Clamer in the chair. Present, forty-two members and visitors.

The minutes of the stated meeting of Thursday, January 31st, were read and approved.

The president introduced the speaker of the evening, Dr. David T. Day, of the U. S. Geological Survey, who delivered an address on "The Black Sands of the Pacific Coast." The speaker illustrated his theme by the exhibition of a number of lantern slides.

Discussed by Mr. Clamer, Mr. Anderson, Dr. Ed. Goldsmith and the author.

The thanks of the meeting were voted to the speaker of the evening.

Adjourned.

Wm. H. Wahl, *Secretary.*

Mechanical and Engineering Section.—Stated meeting held Thursday, May 23d, at 8 P. M. President Chas. Day in the chair. Present, 138 members and visitors.

The paper of the evening was read by Mr. James B. Bonner, of Philadelphia, on "The Present Condition of the Work on the Panama Canal." The speaker gave an account of this important work, based on personal observations made in a recent visit to the Isthmus. His remarks were profusely illustrated with the aid of lantern photographs made from pictures taken on the ground.

The thanks of the meeting were voted to the speaker for his extremely interesting address, and the session was adjourned.

Kern Dodge, *Sec'y pro tem.*

The Franklin Institute.

(Proceedings of the stated meeting held Wednesday, June 19th, 1907.)

Hall of the Franklin Institute,
Philadelphia, June 19th, 1907.

Vice-President James M. Dodge in the chair.

Present, thirty-five members.

Additions to membership since last report, three.

The Actuary, by instruction of the Board of Managers, transmitted a memoir on "The Speed of the Invisible Portions of the Spectrum," signed by "Algol," which had been received in competition for the Boyden Premium. With the memoir the Actuary also submitted the report of a special committee of judges, consisting of Mr. Hugo Bilgram, Prof. A. W. Goodspeed, and Dr. George Flowers Stradling, recommending that the original amount of the Boyden Premium, to wit: one thousand dollars, be awarded to the author of the memoir, Dr. Paul R. Heyl, of Philadelphia, for his successful experimental demonstration of a portion of the proposition stated by Mr. Boyden.

The Actuary likewise transmitted the following resolution adopted by the Board of Managers in reference to the subject, viz.:

"*Resolved*, That the Board of Managers hereby recommends to the Institute the approval of the report of the Judges upon certification from the Judges that they consider any further experimental demonstrations unnecessary." (A certification to this effect, signed by all the Judges, was found appended to the Judges' report.)

The following is an abstract of the applicant's thesis, prepared by the chairman of the Judges, viz.:

"The applicant, 'Algol,' for the Boyden premium has succeeded in demonstrating, by experiment, that those of the ultra-violet rays of light for which glass is transparent, have the same velocity as the light rays proper.

"He reasons that if the velocity of these rays were different they would not arrive, from a distant source, at the same time. For his

tests he selected 'Algol,' a well-known variable star in the constellation Perseus, as the source of light. By means of a diffraction grating he eliminated all but the ultra-violet rays of a known frequency, and by focusing them on a sensitive plate, obtained photographs of the star.

"For the purpose of identifying the rays so recorded with the visible rays, regarding the time of their emission, he selected, for the time of his tests, the time during which the light of this star shows the peculiar phenomenon of fading and recovering. The period of this variation is known to be about six hours. During this period he took a number of photographs, one-half hour apart, each exposure being twenty minutes, the remaining ten minutes being employed for making the necessary preparations for the next exposure. He thus obtained a number of exposures of the star on the same sensitive plate, but shifted in position. After developing the plate, the successive images plainly showed a fading and recovering, and although the exact location of the minimum brightness could not, in the nature of things, be absolutely determined, the approximate coincidence of the time of the minimum brightness of the visible and the photographed rays was obvious. These tests were repeated a number of times to eliminate the possibility of error and also to take in a certain range of the ultra-violet rays, and since favorable opportunity for making these tests is not frequent, the investigation extended over a period of two years.

"The applicant then reasoned as follows: Assuming that the photographic minimum did not exactly coincide with the observed visual minimum, their difference did certainly not exceed an hour, and since the distance of Algol is no less than forty light years, the difference of the velocities of the ultra-violet and the visual rays could not exceed one part in 250,000. This close approximation established equality to all intents and purposes."

After the reading of the foregoing abstract, the presiding officer announced the subject open for consideration.

Mr. Hugo Bilgram, chairman of the Committee of Judges, announced that he was prepared to make any explanation in reference to the work of Dr. Heyl that should be asked for.

Mr. Levy remarked that an interesting feature of Dr. Heyl's memoir was that it was a piece of original scientific research, for the neglect of which Americans have been frequently reproached.

A motion was thereupon unanimously passed confirming the award as recommended by the Judges and endorsed by the Board of Managers.

The Secretary reported the following vacancies in the Committee on Science and the Arts, viz.: Messrs. Amos P. Brown, J. Logan Fitts, C. J. Reed, Geo. P. Scholl, Frank Shuman, H. W. Spangler, A. H. Stewart, J. C. Trautwine, Jr. The following were duly nominated and elected to fill the vacancies:

Dr. G. H. Meeker in place of Prof. Brown; Chas. Zentmayer in place of Mr. Reed; Robert Job in place of Dr. Scholl; Carl G. Barth in place of Prof. Spangler; Richard Zeckwer in place of Dr. Stewart; Luther D. Lovekin in place of Mr. Fitts; Joseph H. Burroughs in place of Mr. Shuman; Mr. Henrick V. Loss, in place of Mr. Trautwine.

The following communications were presented:

The Holophane System of Illumination, by Mr. A. J. Marshall, Illuminating Engineer of the Holophane Glass Co., New York.

Asbestos Fireproof Materials for Buildings (flooring, siding, shingles, etc.), made by Keasby & Mattison, of Ambler, Penna. The subject was presented by Mr. Weldon Clark, the local representative of the manufacturers.

An improved Draughting Board was exhibited and described by Mr. Jos. W. Bramwell, of Philadelphia.

The subjects of the last two communications were referred to the Committee on Science and the Arts, and the thanks of the meeting were voted to the several speakers.

Adjourned.

Louis E. Levy, *Sec'y pro tem.*

Committee on Science and the Arts.

(*Abstract of proceedings of stated meeting held Wednesday, June 5, 1907.*)

Dr. Wm. O. Griggs in the chair.

The following report was adopted:—

(No. 2402.) *A Re-discovered Lost Art.* Frank Della Torre, of Baltimore, Maryland.

This report was made advisory.

The following reports passed first reading:—

(No. 2392.) *Improvements in Diffraction Color Photographs.* Herbert E. Ives, of Weehawken, N. J.

(No. 2400.) *Improved Primary Battery.* Frank A. Decker, of Philadelphia, Pa.

(No. 2409.) *Diffraction Color Photographs.* Prof. R. W. Wood, of Baltimore, Md.

Deferred Business.—(No. 2389.) *Improved Thermometer Support.* Dr. T. F. Townsend, of Philadelphia, Pa.

A motion for reconsideration of the Committee's action in the above-named case was passed and the subject was again brought before the Committee for action. A motion to change the award from the grant of a certificate of merit to the grant of the Edward Longstreth Medal of Merit was made and upon being put to vote, was lost, by a vote of nine ayes to two nays, the remaining three members present declining to vote.

New Business.—The names of the following gentlemen were reported as having resigned from the committee:

Messrs. A. P. Brown, J. Logan Fitts, C. J. Reed, Geo. P. Scholl, Frank Shuman, Dr. A. H. Stewart, J. C. Trautwine, Jr., and Prof. H. W. Spangler.

A special committee, consisting of Messrs. Christie, Levy, Donaldson and the Chairman and Secretary, ex. off., was appointed to present nominations to fill these vacancies at the stated meeting of the Institute, to be held on Wednesday, the 19th inst.

Adjourned.

Wm. H. Wahl, *Secretary.*

FIG. I

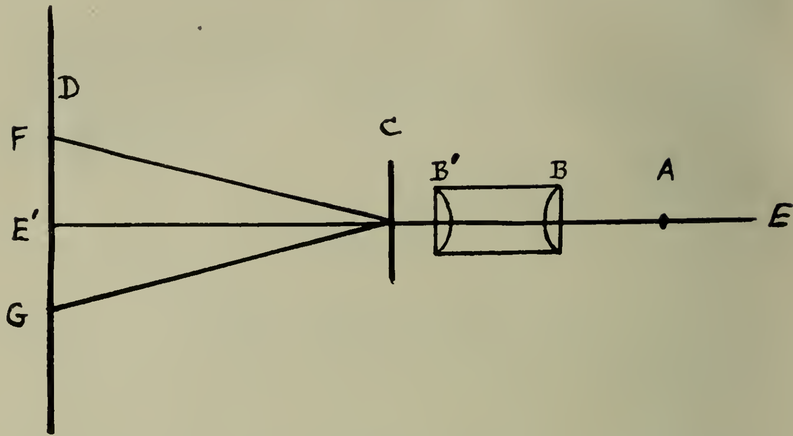
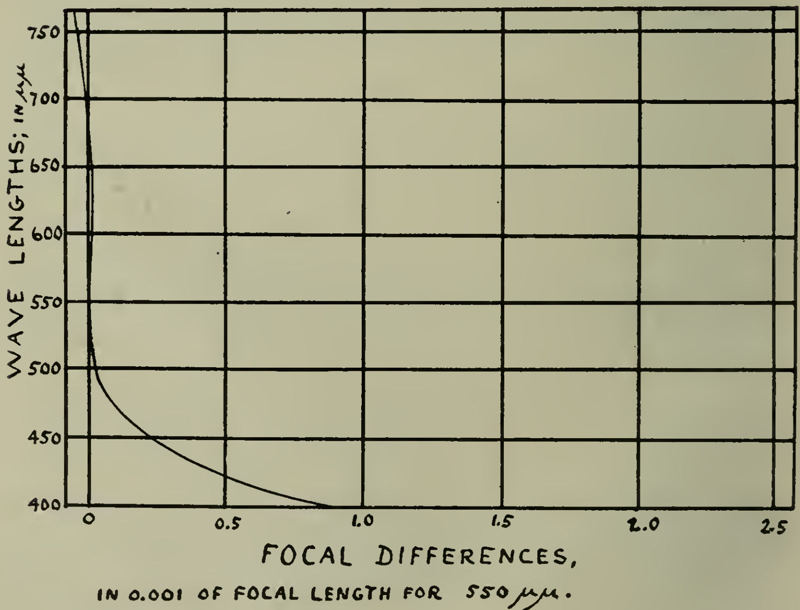

D
F
C
B′
B
A
E′
E
G

FIG. II.


WAVE LENGTHS; IN μμ
750
700
650
600
550
500
450
400
0
0.5
1.0
1.5
2.0
2.5
FOCAL DIFFERENCES,
IN 0.001 OF FOCAL LENGTH FOR 550 μμ.

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FOR THE PROMOTION OF THE MECHANIC ARTS

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The Franklin Institute is not responsible for the statements and opinions advanced by contributors to the *Journal*.

THE FRANKLIN INSTITUTE.

(Stated meeting held Wednesday, June 19th, 1907.)

On the Speed of the Invisible Portions of the Spectrum.

[*A Memoir submitted to the Franklin Institute for the Boyden Premium.*]

BY DR. PAUL R. HEYL.

HISTORICAL INTRODUCTION.

The question for the solution of which the Boyden Premium is offered is one that must be well understood if it is to be well answered. The vagueness of language in the original statement of the question ("all rays of light and other physical rays") is in large measure due to the incomplete and vague knowledge of the spectrum which existed fifty years ago. It may help to understand what might have suggested such a problem if we briefly review the history of the subject of radiation during the first half of the nineteenth century.

In the year 1800, our knowledge of the spectrum was substantially where Newton left it more than a hundred years before; but it was not to be long before two important discoveries were to be made which would greatly enlarge the field of study. In 1800 Herschel discovered the existence of invisible heat-rays beyond the red, and this discovery was quickly followed by the discovery of the ultra-violet rays by Ritter in 1801. A controversy over the nature of these invisible rays at once began, and continued for upwards of two generations. One school of philosophers held that there were three distinct types of rays present in light, namely, the heating, the visual, and the actinic rays. These rays were believed to overlap each other somewhat in refrangibility, accounting for the heating effect in the red and orange and for the chemical effect of the blue and violet. The other school put forth an explanation in terms of the undulatory theory, which was then having its early struggle for recognition. This explanation supposed all kinds of rays to be of the same nature, *i. e.,* undulations in an æther, but to differ somehow in quality or intensity which rendered some of them invisible. Biot was probably the earliest champion of this theory,* and defended it ably as early as 1814. Probably because the undulatory theory on which it was based was not yet generally accepted, this theory seems to have made but little headway for a time.

The progress of the undulatory theory of light may be said to have been quite encouraging by 1833, in which year Brewster, one of the last adherents of the corpuscular theory, wrote these words:†

"On these grounds I have not ventured to kneel at the new shrine, and I must even acknowledge myself subject to that national weakness which urges me to venerate and even to support the falling temple in which Newton once worshipped."

With the gradual recognition of the undulatory theory there seems to have been an increase in the support of what may be called the unitarian theory of the spectrum, and we find Ampère defending and expounding it in 1832.‡ It should be noticed that Ampère does not seem to have grasped the idea that the invisible

*Gilbert's Annalen, 46, p. 376, (1814); Rosenberger, in his Geschichte der Physik, vol. iii, p. 317, credits him with these views in 1825.

†Phil. Mag. (3) ii, p. 360, (1833).

‡Bibliothèque Univ., vol. 48, p. 225; also Pogg. Ann., vol. 26, p. 161, 1832.

PLATE 1.
Experimental, showing appearance of spectra.

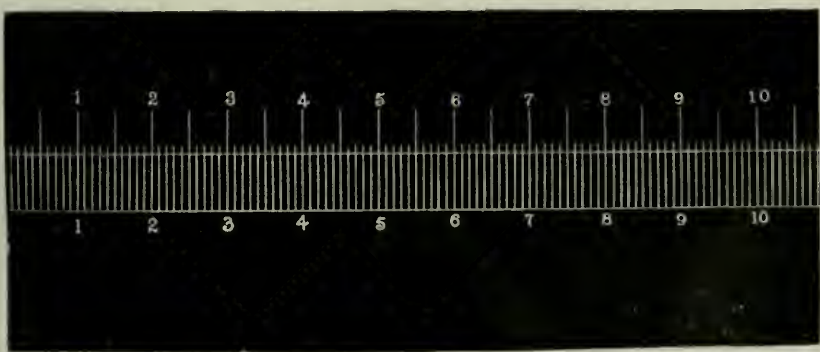

PLATE 4.
Scale of millimeters for measuring wave lengths.

PLATE 2.
Determination of relation between focus and wave length.

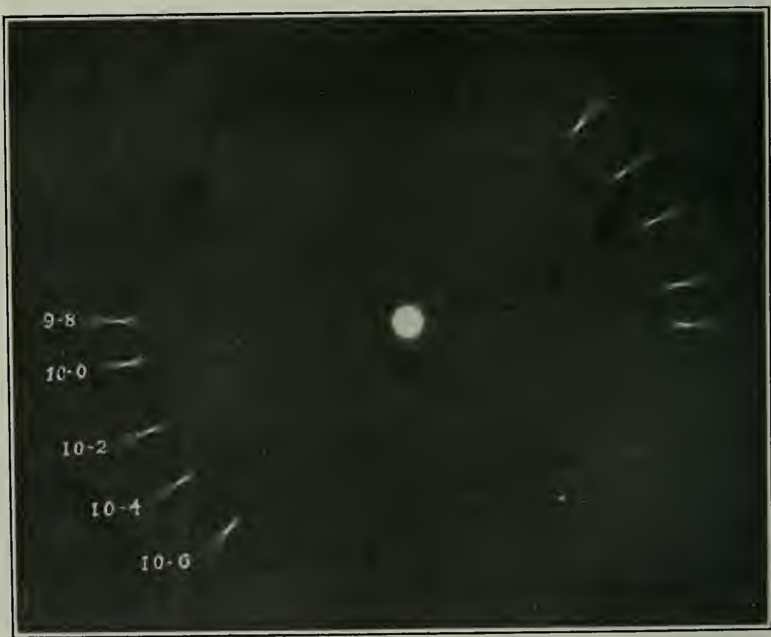

PLATE 3.
Determination of relation between focus and wave length.

waves differ in *frequency* from their visible brethren. He explained the invisibility of heat waves entirely as a question of relative intensity or abundance, and observing that water readily stopped the heat waves, concluded that it was to their absorption by the fluids of the eye that they owed their invisibility.

Melloni, who was easily the greatest authority on radiant heat at that time, combated this theory for some years, but finally capitulated, in 1842.† Yet as late as 1846‡ it was said "the identity is not yet firmly enough established."

The method which was pursued in establishing the identity of the different types of rays in the spectrum was that pointed out by Biot, in 1814. He says, in the article in Gilbert's Annalen already quoted:

"Ob der Waermestoff und das Licht blosse Modificationen eines und desselben Princips, oder zwei wesentlich verschiedene Principe sind, darüber ist seit langer Zeit unter den Physikern und den Chemikern gestritten worden. Man hat zu Gunsten der einen wie der andern dieser Hypothesen, Systeme aufgebaut; der einzige Weg indess, auf dem sich die Sache entscheiden laesst, ist, die Eigenschaften, welche dem Waermestoff, und die, welche dem Lichte wesentlich eigen sind, durch genaue Versuche mit Zuverlaessigkeit auszumitteln, ihre Aehnlichkeiten und die Verschiedenheiten beider auseinander zu setzen, und nachzuforschen, ob ein und dasselbe in seiner Natur unveraenderliche Princip, das auf unsere Organe und auf die Kőrper nach Verschiedenheit der Umstaende Verschieden wirkt, die mannigfaltigen Wirkungen, welche wir wahrnehmen, in ihnen hervorzubringen vermag."

It is rather remarkable that the difference of opinion as to the nature of the various rays of the spectrum seems to have found its main expression in the question as to the identity of light and radiant heat, comparatively little discussion arising over the associated question of the nature of the ultra violet rays. Much work was done in reference to the properties of radiant heat along the lines indicated by Biot, as may be seen from the following summary:

Double Refraction and Polarization by Reflection; Berard, 1812. (Mém. de phys. et de chim. de la Société d'Arceuil, tom iii,

†Comptes Rendus, 15, p. 454; Pogg. Ann., 57, p. 300.

‡Fortschritte der Physik, II, p. 166.

pp. 24-29, 46, 1812. Also Gilbert's Annalen, 46, p. 376, 1814.)

Reflection and Rectilinear Propagation had been previously shown by Mariotte. (See Biot's article in Gilb. Ann., loc. cit.)

Polarization by Transmission; Forbes, 1835. (Edin. Trans. 13, p. 131; Pogg. Ann. 35, p. 553.)

Diffraction; Knoblauch, 1846. (Pogg. Ann., 74, p. 9. Communicated to Berlin Phys. Gesellschaft on Aug. 7, antedating Fizeau and Foucault.)

Magnetic rotation; Desains and De la Provostaye, 1849. (Comptes Rendus, 29, p. 352.) These authors refer to the previous work of Wartman, 1846, who obtained some uncertain results, not confirmed by others.

Speed of Propagation; Baron F. von Wrede, 1840. (Pogg. Ann. 53, p. 602, 1841. Phil. Mag., 20, p. 379, 1842.) This article being in line with the subject of the present memoir merits some extended notice, the more so as its results are at variance with the general belief at the present day. The principle was that if light and radiant heat travel at different speeds they ought to show different aberrations. In consequence, the light and heat images of the sun in a telescope will not exactly coincide, but will be slightly displaced in the direction of the plane of the ecliptic; hence the heat from the eastern and western edges of the sun will not be equal.

To investigate this question a linear thermopile was so mounted in the focal plane of a ten-foot telescope that its edge could be moved across the field of vision by a micrometer screw. The usual eye-piece was in position behind the thermopile so that the edge of the latter could be brought by visual observation tangent to the sun's edge. With the sun's image central in the field, and using a low power, so that the whole disc was visible, the thermopile was brought tangent to the western edge, the adjustment maintained as steadily as possible for five minutes by the driving mechanism of the telescope, and readings of the galvanometer were taken continually. The tube containing the thermopile and the eye piece was then turned through 180°, so that the thermopile now became tangent to the eastern edge, and the readings of the galvanometer were repeated. A single pair of readings like this should, if all adjustments were perfect, indicate qualitatively any considerable shift of the light and heat images. To make the experiment quantitative the pile was moved toward the sun's center

by one turn of the micrometer screw, and the pair of readings was repeated. A series of measurements was made, moving the pile between each pair of readings. In this way it could be ascertained how much more the screw had to be turned on one side than on the other to give the same heat. Half of this displacement of the pile would be the shift of the two images.

Wrede seems to have made but two such complete series of measurements, only one of which was carried out under perfect conditions. During the other there were slight clouds passing now and then, and a strong wind shook the instrument. In both series, however, he believed that he found the east edge of the sun to be hotter than the west edge, which would indicate a greater aberration and a lower speed for the heat rays. The telescope was rotated on its axis between two series to eliminate any unsymmetrical absorption by the object glass. The mean result gave as the shift of the images 0.28 pitch of the screw, which was $\frac{1}{119}$ of a Swedish decimal inch. The focal length of the telescope being 101.5 Swedish decimal inches, the difference between the two aberrations was apparently

$$\tan^{-1}\left(\frac{0.28}{119 + 101.5}\right) = 4.78''$$

The aberration of visible light being a little over 20″, this result gave a speed for the heat rays of about four-fifths that of visible radiation.

This remarkable result attracted no little attention at the time of its publication. Appearing originally in a little-known Danish journal it was copied into Poggendorff's Annalen and the Philosophical Magazine. There is in the possession of the Franklin Institute a letter of Mr. Boyden's, showing that he was acquainted with Wrede's work and also throwing some light upon his construction of the prize question. Mr. Boyden had no confidence in Wrede's result, and calls his work "erroneous;" but he says that it was not his intention to limit the award of the premium to such questions as that attacked by Wrede, but to include any and all other physical rays. He says in another place that he has no evidence either for or against the existence of different rays of the same refrangibility.

Wrede's work is now forgotten, but scientific opinion to-day will share Mr. Boyden's scepticism as to its value. The fact that

it has been forgotten in spite of the publicity given it at the time would seem to indicate that Mr. Boyden but voiced the contemporary opinion of its value. The principal reasons for this distrust may be mentioned.

The constant of aberration of light is such a small quantity that any experiments on differences of this value must be capable of coarse results only. It is generally believed that any difference of speed such as the prize question suggests and Wrede sought would be of an order too small to be capable of detection by Wrede's method. The grounds for this belief will be later referred to.

Wrede's method is based upon the assumption that the surface of the sun is uniformly heated, which the phenomenon of sun spots might render us rather cautious about accepting.

The scanty observations offered by Wrede are not enough to ensure the elimination of the various errors incident to such a measurement. A slight error in centering the sun's disk, or a small change in the rate of the driving clock, or a lack of accuracy in the adjustment of the thermopile tangent to the edge of the sun would have given a false result. In particular it is to be remarked that the tangent position of the thermopile is one of the greatest delicacy; for in no other position on the sun's disk would there be so great a change in the heat received by the pile for a small displacement of the latter.

Apart from the work of Wrede no investigation of the speed of travel of the invisible rays of the spectrum appears ever to have been made up to the time of the establishment of the Boyden Premium, or indeed, up to the present time. While in many other properties the invisible rays were shown to behave in the same manner as their visible brethren, and sufficient evidence was finally amassed to satisfy the scientific world as to their identity, yet the similarity of their speeds, which naturally follows, has never yet been experimentally proven. This last piece of confirmatory evidence was lacking. True, it was not urgently needed; but may this not have been the germ of suggestion in Mr. Boyden's mind which later developed into the idea of establishing the Premium?

Let us now see what work has been done bearing on this subject since Mr. Boyden's day.

It is generally understood at present that all visible radiation

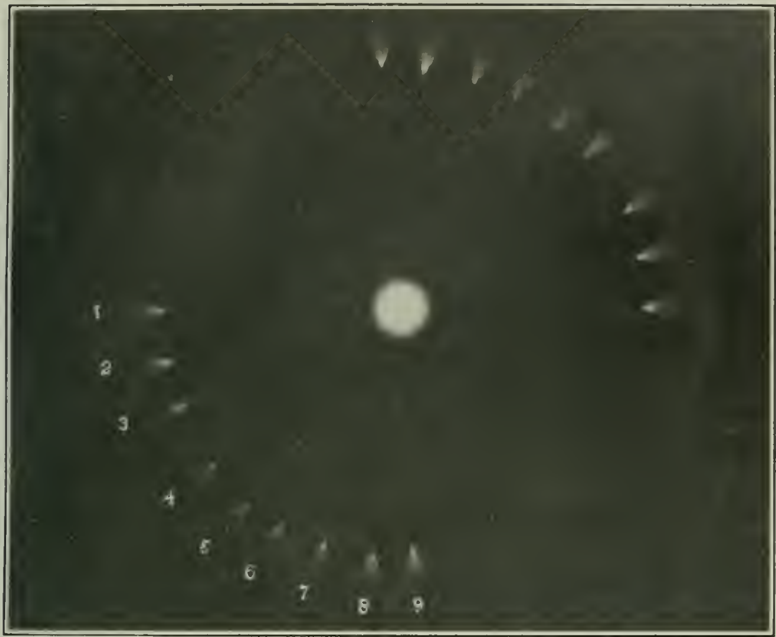

PLATE 5.
Minimum of October 13, 1905. Wave lengths, 373-383 $\mu\mu$

PLATE 6.
Minimum of October 13, 1905. Wave lengths, 416-468 $\mu\mu$

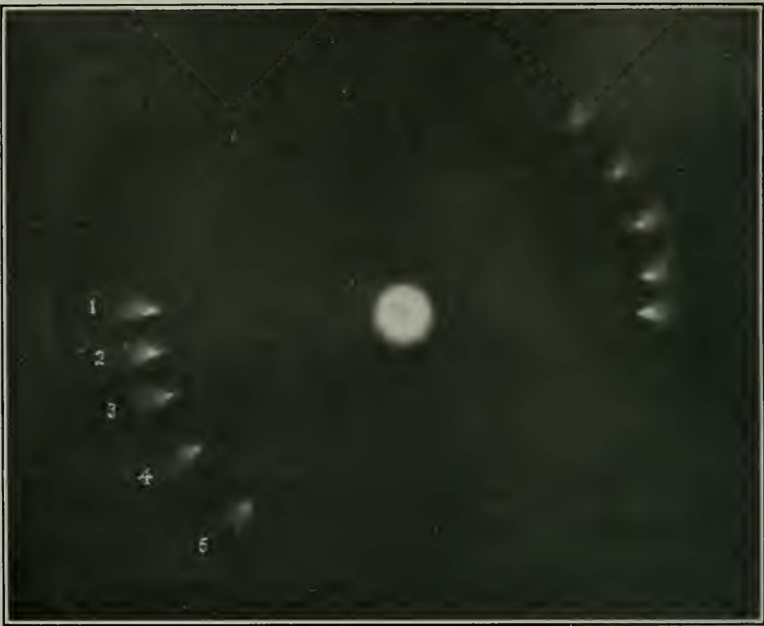

PLATE 7.
Minimum of November 2, 1905. Wave lengths, 370-378 $\mu\mu$

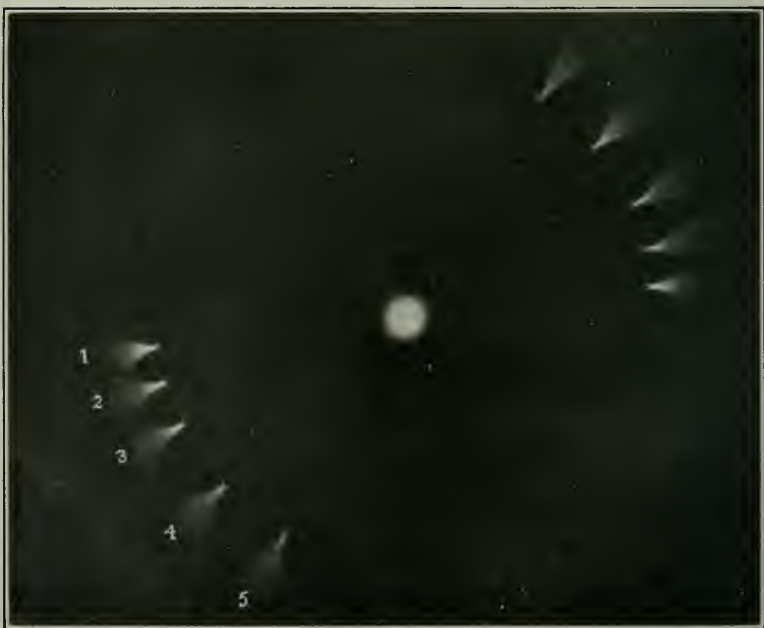

PLATE 8.
Minimum of November 2, 1905. Wave lengths, 378-389 $\mu\mu$

travels with the same speed in vacuo. This seems to have been tacitly assumed before Mr. Boyden established the Premium, probably as a mathematical consequence of the undulatory theory of light. Since that time this doctrine has not passed unchallenged by experiment, but has survived all adverse criticism, and is now quite firmly grounded.

In 1882, Young and Forbes* announced that in making some experiments on the speed of light by a modification of Fizeau's method they had observed that the luminous image was of a reddish cast while increasing in brightness and bluish while decreasing. This, they showed, could be accounted for by a difference in the speed of travel; and from their observations they deduced a difference of nearly two per cent. between red and blue light, the latter apparently traveling the faster. Shortly after this Michelson† repeated his measurement of the speed of light by Foucault's method, and paid particular attention to the question raised by Young and Forbes. He covered one-half of his luminous slit by a piece of red glass, leaving the other half uncovered, and could not detect the slightest break in the continuity of the reflected image; whereas a difference of speed of the magnitude announced by Young and Forbes would have drawn out the image of the slit to a spectrum ten millimeters wide. It seems altogether likely that the effect noticed by Young and Forbes was physiological and subjective. They may have unwittingly discovered what is now known as the Purkinje phenomenon, or at any rate something of the same nature.

All these experiments referred, of course, to the speed in air; but the refractive index from air to a vacuum is so nearly unity for all colors of light that no doubt exists as to the truth of the proposition in vacuo.

But astronomy furnishes us additional evidence for the case of light in vacuo. At the times of the eclipses of the satellites of Jupiter no change of color can be observed as the satellite disappears and reappears. Here the portion of the path of the light that lies through air is utterly insignificant compared with the length of the path in vacuo; and the distance of Jupiter is such

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*Phil. Trans. part I. 1882.

†Astronomical Papers for the American Ephemerics and Nautical Almanac, Vol 2.

that a difference of speed of two per cent. between red and blue light would, as pointed out by Young and Forbes, amount to a lag of about half a minute between these two colors.

Still more conclusive is the evidence furnished by short period variable stars, none of which show any appreciable change of color in their waxing and waning, although undoubtedly at enormous distances. We may therefore conclude that the uniform speed of visible radiation in vacuo is a settled question.

This fact of the uniformity of speed of the waves making up the octave of the visible spectrum is an important one when we consider the question of a possible difference of speed in the invisible portions. All analogy with other forms of wave motion leads us to the conclusion that if the speed be constant for any considerable range of wave lengths it will also be constant, or nearly so, for wave lengths outside that range. In the case of gravitational waves in deep water, where the speed is a function of the wave length, there is no range of wave lengths, however limited, where the speed is constant; and in the case of sound waves in air the speed is constant over the nine or ten octaves that constitute the range of audibility if it is constant over a single one. For this reason we are inclined to expect the speed of the invisible rays to be nearly the same as that of the visible rays, and to distrust such a result as that announced by Wrede until it has been independently confirmed.

In view of the foregoing considerations it may be deemed a useless expenditure of time to apply to the investigation of the prize question any method except one of the most delicate description. The method about to be described by the writer may be trusted to show a difference of one part in two or three hundred thousand in the speed. Being photographic in its nature it has been found practicable to apply it only to the ultra violet and visible region of the spectrum; but as the results confirm the hitherto existing belief in the constant speed of travel so far as ultra-violet region is concerned, it becomes in the highest degree improbable that the ultra red region should exhibit any marked deviation from this speed.

PRINCIPLE AND DETAILS OF THE METHOD.

Let there be a source of white light at a great distance from the observer, and suppose this source to suffer a periodic variation in

intensity. Let the light which reaches the observer be dispersed into a spectrum by a prism or a grating. If all the different components of the white light travel with the same speed every part of the spectrum will have its maximum or minimum of intensity at the same moment; but if the speed is a function of the wave length this will not be the case.

All this, of course, is equivalent to saying that the light from the distant source will suffer a periodic change of color with its change of intensity; but in the above form the principle is applicable also to the invisible regions of the spectrum.

We are speaking in terms of Newton's hypothesis that the different periodicities of the spectrum may be considered as physically present in white light because physically present in the source. The more recent theory is that white light is due to irregular pulses in the source; that the different colors are to be considered as only mathematically present in the white light, and as physically manufactured by the prism or grating. This theory does not in the least affect the validity of the reasoning upon which this method is founded any more than it upsets the conclusions of celestial spectrum analysis. To restate the matter in terms of the pulse theory we should say that if the speed is constant for all wave lengths the pulse will travel without change of form, and if analyzed by the observer will present a simultaneous variation in intensity in all its components; while if the speed is a function of the wave length the pulse will alter its form as it travels, and when it reaches the observer it may have a differently proportioned set of components from those with which it started. As we are not concerned with the question of what periodicities are physically present in the source we shall use the Newtonian method of expression on account of its greater simplicity.

The only source of light at a practicable distance for such an experiment is a star; and such a source has the added advantage of enabling us to deal with the speed of light in vacuo, as the time taken by light to traverse the earth's atmosphere is so minute that no appreciable time lag between the different components could be introduced by the air.

We have in the star Algol (β Persei) an almost ideal source of light for such an experiment. This star shines ordinarily with a uniform lustre of about the second magnitude, but once in about three days (more exactly 2 days, 20 hours, 48.9 minutes) it suf-

fers a rapid diminution in brightness and an equally rapid recovery, occupying some seven hours in all, and involving a change in brightness of over one magnitude. This change has long been suspected to be due to a dark body revolving round Algol and eclipsing it periodically, and Vogel's measurements of the motion of Algol in the line of sight have recently put this hypothesis upon a pretty sure footing. He found that 17 hours (one-quarter of the star's period) before the minimum the star was moving away from us with a maximum speed; and 17 hours after the minimum the star was approaching us with a maximum and equal speed. This is exactly what should occur if the star were revolving around the common center of gravity of itself and a dark companion. Here, then, we have a source of light in which we can be sure that all the components have their minimum impressed upon them at the same instant.

And this source is at an enormous distance. Two attempts at measuring its parallax (by Chandler and Chase, respectively) gave the figures 0.07″ and 0.04″, the only conclusion from which is that the parallax is certainly less than 0.1″ and the distance therefore not less than about thirty light years.

This great distance enables us to make a very delicate comparison of the speeds of the different wave lengths; for suppose two waves travelled with speeds which differed by only one part in a million; then the minimum impressed upon the more rapidly travelling train of waves would reach us one millionth of thirty years, *i. e.*, about *sixteen minutes* before the other.

To carry out this method one must make determinations of the intensity of the different portions of the spectrum of the star, both visible and invisible, at intervals during its waning and waxing. Should all parts of the spectrum be found to have their minimum at the same moment, or, what amounts to the same thing, should the instant of minimum for every region of the spectrum be the same as the time of the visual minimum as given by the ephemeris, then the speed of travel is independent of the wave length.

In the experiments here described the comparisons of the intensities were made photographically. A suitable sensitive plate was exposed to the spectrum of the star, and a number of successive and equally timed exposures were made on the one plate, extending over a period of four or five hours, and so arranged that the

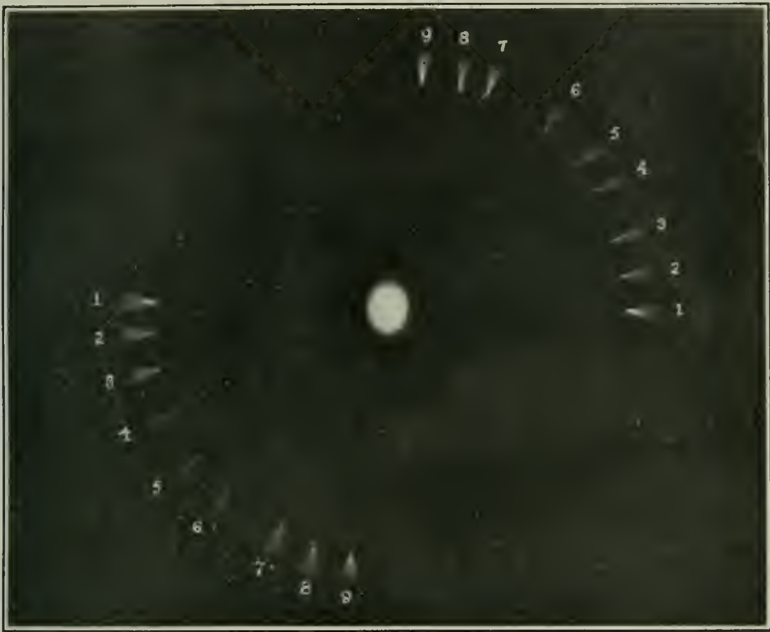

PLATE 9.
Minimum of November 5, 1905. Wave lengths, 383-400 $\mu\mu$

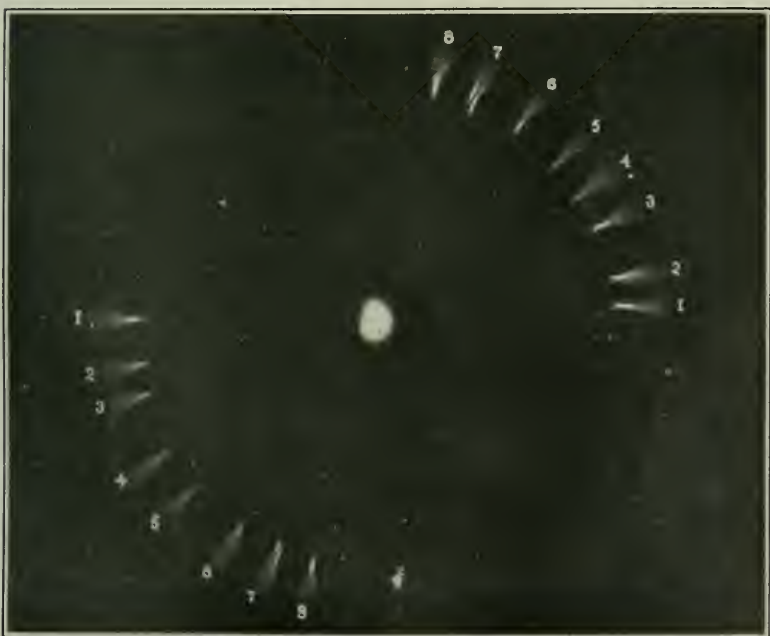

PLATE 10.
Minimum of November 5, 1905. Wave lengths, 416-468 $\mu\mu$

PLATE 11.
Minimum of September 5, 1906. Shortest wave length, 356 $\mu\mu$

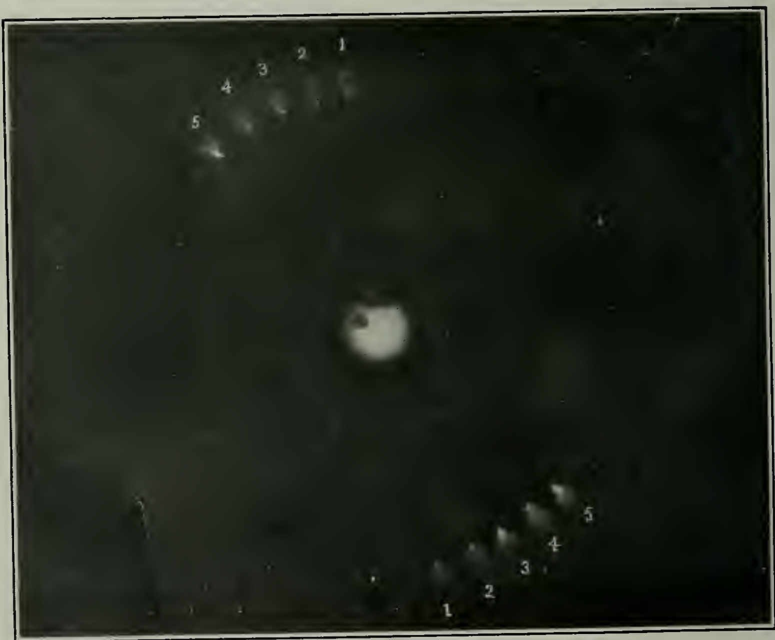

PLATE 12.
Minimum of September 5, 1906. Shortest wave length, 365 $\mu\mu$

instant of visual minimum, as given by the ephemeries, should be midway in the central exposure of the series. If, when the plate was developed, every portion of the spectrum exhibited its minimum of intensity on the same photographic image, the speed is the same for all wave lengths. Should this image be not the central one of the series, it would mean that the ephemeris was in error. The effect produced by a difference of speed of travel would be to cause the minima of intensity for different regions of the spectrum to appear on different images.

In practice it was found impossible, except for a portion of the visible spectrum, to get any great range of the spectrum in focus at one time, and many plates were necessary. Ordinary commercial instantaneous plates (Seed) were used in photographing the spectral images; and as the question was simply one of the relative intensities of the different portions of the spectrum, and the spectral lines were of no importance, the operation was a comparatively simple one.

The photographs were taken with an eight-inch equatorial telescope and an ordinary photographic camera. The lens was removed from the camera and replaced by a transparent diffraction grating (a Wallace replica) so mounted that it could be turned through any desired angle while always remaining parallel to the sensitive plate. In this way a series of radially arranged images could be taken on the same plate. The camera with the grating was attached by a light and rigid mounting to the eye-piece tube of the telescope. The optical parts are shown in schematic arrangement in Fig. 1 below.

EE^1 represents the optic axis of the telescope; the image of the star is formed by the object glass at some point A on this line. This point is in one of the conjugate foci of the eye-piece, BB^1, of the telescope; the other conjugate focus is at E^1, on the sensitive plate D. At C the grating is interposed, which produces two first order *streak* spectra at F and G. The focusing is done by altering the distance AB by moving the eye-piece tube in and out, carrying with it the camera and grating.

Plate 1* shows the appearance of the spectra thus photographed.

*The photographic effects obtained in the negatives of the accompanying plates have been more or less emphasized in the positives for the purpose of typographic reproduction. Editor.

The plate is merely an experimental one and is of no other importance. Two exposures were made, turning the grating through 90° between the exposures. It will be noticed that the spectral images are not strictly streaks, but widen out fan-wise at the inner or violet end. The reason is simply that this portion is out of focus. The focus was adjusted for the visual rays, and the best that modern optical science can do is to achromatise a lens for the region from the red to the blue. From this point out into the ultra violet the focus changes rapidly for a small change in wave length. The diagram shown in Fig. II is taken from Müller-Pouillet's Lehrbuch der Physik, and shows the usual relation between wave length and focal length for the best modern achromatic combinations.

It is this lack of achromatism in the object glass of the telescope that causes the fan appearance. The object glass brings to the point A (Fig. 1) only the rays from the red to the blue. The violet and ultra violet images are to be found at various distances from A along the line EE^1. Consequently the eye-piece cannot bring them to a focus at one point. And so rapidly does the focus for these short rays change with the wave length that it is impossible to get more than a limited range in focus at once.

Plates 2 and 3 were taken with the eye-piece in different positions to ascertain where the eye-piece should be set in order to bring any particular wave length into focus. The eye-piece tube had engraved upon it a scale of centimeters and tenths, by means of which it was easy to record and reproduce the position of the eye-piece. The numbers scratched opposite the images on the plates refer to this scale.

The determination of the wave length was thus effected: The ruled surface of the grating was always 15 cm. from the sensitive plate, and carried 5684 lines to the centimeter. To determine the wave length of any point it is necessary merely to measure its distance from the undeviated central image of the star, or, what is preferable, half the distance between corresponding points on opposite spectra, and a simple trigonometrical calculation furnishes the wave length.

In measuring these distances the plate 4 is useful. It is merely an engraved scale of millimeters. The following table then gives the wave lengths:

Distance. (from center.)	Wave length.	Distance.	Wave length.
cm.	$\mu\mu$.	cm.	$\mu\mu$.
2.0	232	2.8	324
2.1	244	2.9	334
2.2	255	3.0	345
2.3	267	3.1	356
2.4	278	3.2	367
2.5	289	3.3	378
2.6	301	3.4	389
2.7	312	3.5	400
3.6	411	4.1	463
3.7	422	4.2	474
3.8	432	4.3	484
3.9	443	4.4	494
4.0	453	4.5	505

DISCUSSION OF THE PLATES.

The plates taken during the minimum of Algol may be divided into two series, those taken in 1905 and those taken in 1906. The series of 1905 includes numbers 5 to 10, and the series of 1906 the subsequent numbers. Most of the plates were developed by ferrous oxalate, to obtain the clear glass effect where there was no photographic image; but some of the plates were developed by hydrochinon, and these are easily recognized by the darker character of the background. There are but a few plates in each series because, first, the season during which the star is in a suitable position for an extended series of photographs lasts only about four months, from September to January; and second, because there are only some nine or ten minima of Algol available during the season, the others happening during daylight or so close to sunrise or sunset as to be useless; and third, one must expect these nine or ten to be still further reduced by cloudy weather. The scheme of observations is rather exacting in its weather requirements, as the star should remain unclouded for over four hours. However, a partially completed set of exposures is not without evidential value.

All the plates of the 1905 set are affected with a small error in the time of minimum as marked on the plate, a subtractive correction amounting to about six minutes for October and seven for November. The times of maximum for that year were taken from the ephemeris published each month in the astronomical col-

umn of "Nature," and it was afterward discovered that these times, although not so specified, were really *heliocentric,* that is, not corrected for the time taken by light to cross the orbit of the earth. Were Algol 90° from the ecliptic this correction would vanish; but the angle is only about 22°, and the speed of light must be taken into consideration. This error is not sufficiently large to be serious, as we shall see in discussing the separate plates. In all plates of the 1906 series the time is correctly marked. We shall consider the plates in their chronological order.

PLATES 5 AND 6. MINIMUM, 3.02 A.M., OCTOBER 13, 1905.

It was customary to expose two plates each night, each to a different region of the spectrum. All the exposures on plate 5 lasted fifteen minutes, and were arranged symmetrically in time before and after the supposed time of minimum, 3.08 A.M. The exposures on plate 6 were likewise symmetrical, but were ten minutes each. A study of the following time table, observed on this occasion, will make clear how this was accomplished.

Plate 5.	Plate 6.
1.00-1.15	
	1.17-1.27
1.30-1.45	
	1.47-1.57
2.00-2.15	
	lacking
2.30-2.45	
	2.47-2.57
3.00-3.15	
	3.17-3.27
3.30-3.46	
	3.48-3.58
4.00-4.15	
	4.17-4.27
4.30-4.45	
	4.47-4.57
5.00-5.15	

These exposures were, of course, not left entirely to the driving clock of the telescope, but were constantly guided by the help of a long finder attached to the instrument. The two or three minute interval between exposures sufficed for the performance of the following operations: turning the grating slightly, changing the plate-holder, and altering the focus. By 2.15 A.M. the star had passed the zenith, and it was necessary to reverse the telescope,

PLATE 13.
Determination of relation between focus and wave length.

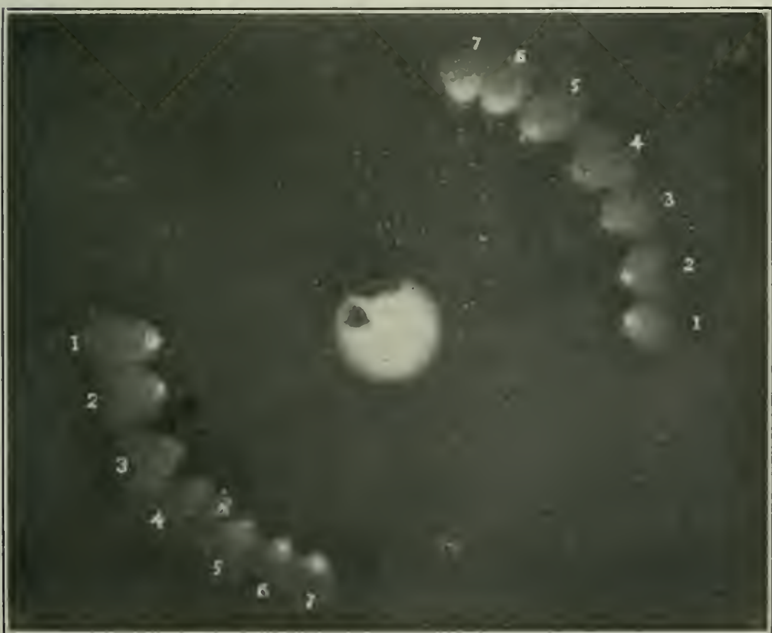

PLATE 14.
Minimum of October 15, 1906. Shortest wave length, 345 $\mu\mu$

PLATE 15.
Minimum of November 7, 1906. Shortest wave length, 345 $\mu\mu$

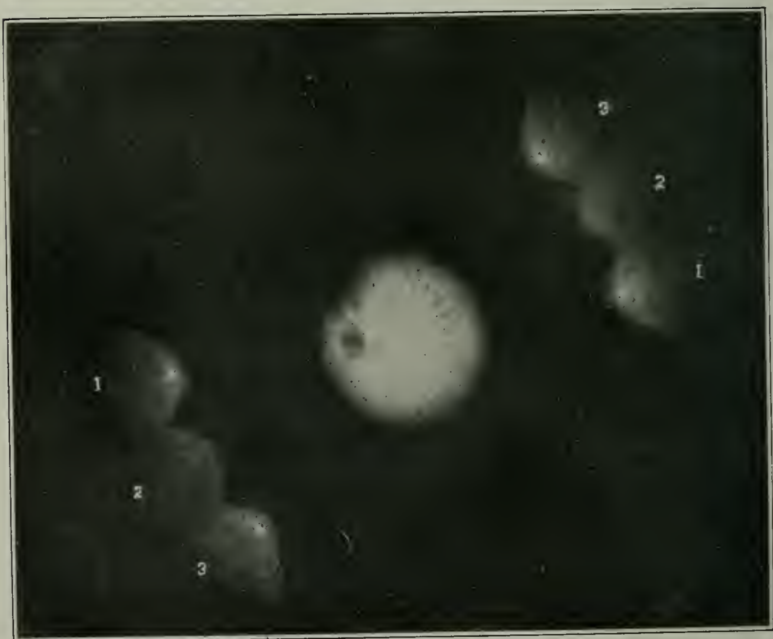

PLATE 16.
Minimum of November 30, 1906. Shortest wave length, 300 $\mu\mu$

swing it to the other side of the pillar and re-sight it. This took more time than was available in the scheduled interval, and consequently the third exposure on plate 6 had to be omitted. During the sixth exposure on plate 5 something attached to the mechanism of the right ascension regulating screw slipped out of place. The exposure was stopped at once, and the loose piece adjusted. This took nearly a minute. The exposure was started again after one minute had elapsed, and was extended one minute later than usual. This necessitated advancing the next exposure one minute to gain sufficient time for the necessary changes. The night was entirely cloudless. Occasionally a faint puff of smoke from a neighboring chimney would pass across the star, but this never occupied more than a second and happened during nearly every exposure, so that its effect on the intensity of the image may be neglected.

By looking through these plates at a white surface, not too brilliantly lighted, the best effect is obtained. It will be seen that the spectral images decrease gradually in intensity and then increase. While the fifth exposure on plate 5 is really the minimum it is impossible to detect any certain difference of intensity between this image and the ones adjoining it on either side, taken half an hour before and after. This shows that the six minute error above mentioned is a negligible quantity. Yet while we cannot with safety locate the minimum visually within a half hour the whole symmetry of the two series of images on this plate makes it certain that the minimum cannot be shifted as much as one hour from the time of the visual minimum as given by the ephemeris. As already mentioned, a difference in speed of one part of a million would produce a time lag of at least a quarter of an hour, and probably more, due to the uncertainty as to the star's distance. Consequently, the rays photographed on this plate do not differ in speed from the rays of the visible spectrum by as much as one part in about two hundred and fifty thousand. Measuring the wave lengths by means of plate 4 and the table given above it will be found that the rays on this plate are comprised within a range of from about 373 to 383$\mu\mu$. While the limit of visibility varies somewhat with different observers it may be considered to lie approximately at the violet potassium line, of a wave length 404$\mu\mu$. The rays on this plate are then entirely in the ultra violet.

In plate 6 the range of wave lengths is between 416 and 468$\mu\mu$, entirely in the visible region. The minimum is supposed to lie between the fourth and fifth images (counting the missing one) and certainly cannot be more than one hour from this. Consequently the speed of these visible rays cannot differ from that of the ultra violet rays on plate 5 by as much as one part in a quarter of a million.

There is one other important point shown by these plates. The star passed the meridian a little before the central exposure of the series, and had atmospheric absorption any sensible effect the intensities of the images after minimum would have been rendered more nearly uniform than those of the first half of the series. We may conclude, then, that for the purpose of this method a distance of as much as three hours from the meridian exerts no effect upon the intensity of the image that is comparable with that produced by the star's own change in brightness.

PLATES 7 AND 8. MINIMUM 4.44 A. M., NOVEMBER 2, 1905.

This minimum happened so near the morning twilight that only the first or waning half was available. The following is the time table, supposing the minimum to have been at 4.51 A.M.:

Plate 7.	Plate 8.
	2.13-2.28
2.30-2.40	
	2.43-2.58
3.00-3.10	
	3.13-3.28
3.30-3.40	
	3.43-3.58
4.00-4.10	
	4.13-4.28
4.30-4.40	

An exposure on plate 8 was started at 4.43, but a faint haze came over the sky almost at once, and the series was terminated. During the rest of the night the weather conditions were perfect. On both plates the images decrease steadily until the end, and we may safely assert that the minimum for the rays there represented does not happen as much as one hour *earlier* than the ephemeris time; consequently the speed of these rays cannot be *greater* than that of the visible rays by one part in a quarter of a million. The rays on plate 7 are between 370 and 378$\mu\mu$, and those on plate 8 between 378 and 389. Both plates deal entirely with the ultra

violet. On this date the star crosses the meridian about half past twelve.

PLATES 9 AND 10. NOVEMBER 5, 1905. MINIMUM, 1.32 A. M. CULMINATION, ABOUT 12.15 A. M.

The time table for these plates was as follows:

Plate 9.	Plate 10.
11.31-11.46	11.49-11.59
12.01-12.16	12.19-12.29
12.31-12.46.	12.49-12.59
1.01- 1.16	1.19- 1.29
1.31- 1.46	1.49- 1.59
2.01- 1.16	2.19- 2.29
2.31- 2.46	2.49- 2.59
3.01- 3.16	3.19- 3.29
3.31- 3.46	

In the above time table the minimum was supposed to occur at 1.39 A.M.

These plates show certain irregularities which are not to be accounted for by passing clouds, as the weather conditions were apparently perfect. In plate 9 it will be noticed that the images numbered 7, 8 and 9 are very much darker than number 1, although in the latter the star was near the zenith and in the former about two hours past it. Moreover, the minimum is much more difficult to detect than in any of the preceding plates. It is certain, however, that 1 is darker than 2. This may be seen to better effect by looking through the plate at a gas flame covered by an opaque globe, such as covers Welshbach mantles, and holding the plates so that the images lie a little off the globe and exhibit an opalescent effect. The minimum is theoretically at number 5, but should it be shifted as far forward as 3, and more than this cannot possibly be claimed, the difference in speed could not exceed one part in a quarter of a million. The range of wave lengths on this plate is from 383 to 400 $\mu\mu$.

In plate 10 very much the same conditions prevail; in addition,

6 is certainly much fainter than 5, although the brightness of the star is on its upward path. It happens, however, that a previous plate (number 6) covers the same range of wave lengths as shown in plate 10, and gives a regular minimum. It must be, therefore, that the irregularity referred to was the result of some disturbance peculiar to the evening on which plate 10 was taken, and of a nature not to be detected by the eye. It may have been some change in humidity or temperature in the upper layers of the atmosphere which produced a weakening of the spectrum at that point and that time. Possibly the very strongly marked final images and the obscure minimum on poth plates may have been due to a progressive increase in the transparency of the atmosphere for the violet and ultra-violet rays during the night. It is obviously impossible to follow such changes by observing the atmospheric conditions in the neighborhood of the telescope, as observations in order to be effective would have to be made all the way up to the top of the atmosphere.

PLATES 11 AND 12. MINIMUM 12.06 A. M., SEPTEMBER 5, 1906.
CULMINATLON, 4 A. M.

The dark background of these plates is due to their having been developed by hydrochinon. The early part of the night was cloudy, and but little more than the last or waxing half of the eclipse could be photographed. The time table follows:

Plate 11.	Plate 12.
11.30-11.42	
	11.45-11.57
12.00-12.12	
	12.15-12.27
12.30-12.42	
	12.45-12.57
1.00- 1.12	
	1.15- 1.27
1.30- 1.42	
	1.45- 1.57
2.00- 2.12	

On both plates there is readily recognized a well marked increase in the intensity of the images after the first two. The minimum consequently cannot be as much as one hour *later* than the minimum of the visual rays, and the speed cannot be *less* than that of the visible rays by as much as one part in a quarter of a million.

The dark background makes it difficult to measure wave lengths on plate 11, but plate 12 is clearer, and the shortest wave lengths reached is about 365 $\mu\mu$. Plate 13 (about to be described) tells us that the shortest wave lengths reached on plate 11 is about 356 $\mu\mu$.

PLATE 13.

This is merely an experimental plate, exposed for half hour intervals at three different foci, to determine the wave lengths reached. It will be noticed that the third exposure, reaching a wave length of about 345 $\mu\mu$, is very much fainter than the two others. Either there is an absorption band in this region or we are approaching the end of the star's spectrum. The exposure in each case was half an hour.

PLATE 14. MINIMUM OF OCTOBER 15, 1906, 3.29 A. M. CULMINATION, ABOUT 1.30 A. M.

But one plate was taken on this occasion, on account of the greater length of exposure necessary. The time from 1.44 to 5.14 was divided into seven half-hour exposures, central about the time of minimum. Through an accidental displacement of the grating the fourth or central exposure was lost, and the plate shows only the three before and the three after minimum. Very little may be safely gathered from the images on this plate; the images are all too faint, and the minimum is not all definite. The shortest wave length reached is about 345 $\mu\mu$. This region of the spectrum was rephotographed on the next available occasion with a longer exposure, and is shown in

PLATE 15. MINIMUM OF NOVEMBER 7, 1906, 2.00 A. M. CULMINATION ABOUT MIDNIGHT.

The time table for this plate was as follows:

11.00-12.00
1.30- 2.30
4.00- 5.00

central about the time of minimum. It will be noted that in addition to increasing the length of the exposure the first and last exposure are placed somewhat farther from the minimum than was the case with any of the preceding plates. The middle of the

terminal exposure is in each case two and a-half hours from the minimum, while in the previous plates it never exceeded two hours. This was, of course, to obtain a greater difference in the intensities of the end and central images.

In examining this plate the first thing that will be noticed is that the images on the right are much darker than those on the left. This may have been caused by using a portion of the grating which threw more light to one side than to the other. There is a very definite minimum evident; in fact the central exposure cannot be seen at all on the right, and can be detected only with difficulty on the left. In looking for this image it will aid in its detection if one notes that the images are somewhat parabolic in shape with a dark nucleus at the vertex. On the left side, the "comet's tail" of number 3 is considerably darker where the tail of number 2 intersects it, and having found this point it is easy to see the nucleus of 2. We may conclude that the minimum for these wave lengths cannot occur as much as one hour from the time of minimum of the visible rays, else the central image would be about equal in intensity to one of the end ones. The visible transparency of the atmosphere was perfect throughout the night. Certain fifth magnitude stars in the neighborhood of Algol were used as tests for this, and were plainly visible at all times during the exposure. We may say then that the speed of ultra violet light as far out as 345 $\mu\mu$ does not differ from the speed of the visible rays by as much as one part in a quarter of a million.

PLATE 16. MINIMUM OF NOVEMBER 30, 1906, 12.31 A. M. CULMINATION, ABOUT 10.20 P. M.

Three exposures were made on this occasion as follows:

10.01-11.01
12.01- 1.01
2.01- 3.01

The focus was adjusted so as to reach rather far into the ultra violet, and the plate shows a wave length of about 300 $\mu\mu$. The images are extremely faint, but can be located by aid of the numbers scratched on the plate. The images are shaped like parabolas, and may best be seen by viewing the plate by reflected light against the background. If a gas flame is used the reflection of the flame should appear on the plate a little to one side of where

the images are supposed to be. The number lies between the images and the central image of the star.

The images on this plate exhibit a well-marked minimum, although the first of the three is in each case somewhat lighter than the third. The middle of the terminal exposures being two hours from the time of minimum, we may safely say that the minimum for the rays here represented cannot have been shifted by as much as one hour from the time of minimum of the visible rays, else the central image would be as dark as one of the end ones; consequently there cannot be a difference of speed as great as one part in a quarter of a million.

RESUMÉ.

The plates submitted with this memoir cover (somewhat discontinuously) the region of the spectrum lying between wave lengths of 468 $\mu\mu$ in the blue to 300 $\mu\mu$ in the ultra violet. The end of the visible spectrum is assumed to lie at about 400 $\mu\mu$. The speed of the rays within this range is constant to one part in a quarter of a million.

It has long been recognized that the speed of the visible rays of the spectrum is constant to a high degree of accuracy, but so far as the author is aware there has never been heretofore any experimental determination, either absolute or relative, of the speed of the ultra violet rays. Their speed, as well as that of the ultra red rays, has on theoretical grounds been believed to be the same as that of the visible rays. The experimental confirmation of this belief for the ultra violet rays adds weight to the generally received opinion as regards the ultra red end of the spectrum.

A FEW WORDS CONCERNING THE ULTRA RED RAYS.

The method described in this memoir being photographic in its nature it would seem hopeless to attempt to apply it to the ultra red portion of the spectrum; yet this matter was carefully tested. As much as twenty years ago plates were made by Abney which were sensitive as far as 1000 $\mu\mu$, although a very long exposure was required for this.

The preparation of these plates is unusually difficult, and they do not keep well. Those who have attempted to repeat Abney's experiments have usually failed, and the author forms no excep-

tion to this statement. However, Lehmann* has of recent years published a method of obtaining with comparative ease a plate which is sensitive as far into the ultra red as Abney's. He stains an ordinary instantaneous plate in an ammonical solution of nigrosin and alizarine blue S, containing a small amount of silver nitrate. The author has carefully tested Lehmann's formula and succeeded in reaching a wave length of 1000 $\mu\mu$ with a Welsbach mantle as the source of light; but the attempt to use these plates on the stars showed at once that the exposure required would be prohibitive, occupying in fact more than a whole night.

It might be possible with a rotating mirror apparatus, such as used by Michelson and Newcomb, and a bolometer to locate the ultra red image, to obtain a result for the ultra red rays accurate to one part in a thousand, possibly; but, as has been pointed out in the early part of this memoir, it would not be worth the great expenditure of time and trouble to apply to the solution of this point a method whose results were of so approximate a nature.†

Appendix A.

THE BOYDEN PREMIUM.

In 1859, Uriah A. Boyden, Esq., of Boston, Mass, deposited with the Franklin Institute the sum of one thousand dollars, to be awarded as a premium to "Any resident of North America who shall determine by experiment whether all rays of light, and other physical rays, are or are not transmitted with the same velocity."*

The following conditions were established for the award of this Premium:

1. Any resident of North America, or of the West India Islands, may be a competitor for the Premium; the southern boundary of Mexico being considered as the southern limit of North America.

2. Each competitor must transmit to the Secretary of the Franklin Institute a memoir describing in detail the apparatus, the mode of experimenting, and the results; and all memoirs received by him before the first day of January, one thousand nine hundred and eight will, as soon as possible after this date, be transmitted to a Committee of Judges.

3. The Board of Managers of the Franklin Institute shall, before the first day of January, one thousand nine hundred and eight, select three citizens of the United States of competent scientific ability, to whom the memoir shall be referred; and the said Judges shall examine the memoir

Arch. für Wissensch. Photog. II, 216, 1900. See also *Baly's Spectroscopy.*

†The author, now that his identity is disclosed, desires to record his obligation to his colleague, Prof. M. B. Snyder, for placing at his disposal the telescope of the Central High School.

and report to the Franklin Institute whether, in their opinion any, and, if so, which of the memoirs is worthy of the premium. And, on their report, The Franklin Institute shall decide whether the Premium shall be awarded as recommended by the Judges.

4. Every memoir shall be anonymous, but shall contain some motto or sign by which it can be recognized and designated, and shall be accompanied by a sealed envelope, endorsed on the outside with some motto or sign, and containing the name and address of the author of the memoir. It shall be the duty of the Secretary of the Franklin Institute to keep these envelopes securely and unopened until the Judges shall have finished their examination; when, should the Judges be of opinion that any one of the memoirs is worthy of the Premium, the corresponding envelope shall be opened, and the name of the author communicated to the Institute. The sealed envelopes accompanying unsuccessful memoirs will be destroyed unopened, in the presence of the Board of Managers.

5. Should the Judges think proper, they may require the experiments described in any of the memoirs to be repeated in their presence.

6. The memoirs presented for the Premium shall become the property of the Franklin Institute, and shall be published as it may direct.

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*The problem has been more specifically defined by the Board of Managers as follows:

"Whether or not all rays in the spectrum known at the time the offer was made, namely, March 23, 1859, and comprised between the lowest frequency known thermal rays in the infra-red, and the highest frequency known rays in the ultra-violet, which in the opinion of the Committee lie between the approximate frequencies of 2×10^{14} double vibrations per second in the infra-red, and 8×10^{14} in the ultra-violet, travel through free space with the same velocity."

Appendix B.

REPORT OF THE COMMITTEE OF JUDGES

On the foregoing Memoir submitted by the author under the pseudonym "Algol."

To the President and Members of The Franklin Institute:

Regarding the application by "Algol" for the Boyden Premium, we respectfully report that the applicant has demonstrated by experiment that the velocities of the visible and the ultra-violet rays are equal, the method of observation yielding such a degree of accuracy that the maximum of possible error cannot exceed one part in two hundred and fifty thousand. This degree of accuracy the Board of Judges deems to be much in excess of that usually expected in problems of this character. The applicant has accordingly furnished the required proof as regards the relation of the visible and the ultra-violet rays. The experimental proof as regards the infra-red rays remains still lacking, the method adopted in this memoir not being suited for those rays.

The Committee, however, considers the work presented to be of such a high character as to be eminently worthy of distinct recognition and

strongly recommends that the applicant be awarded the sum of One Thousand Dollars ($1,000) from the accumulated Boyden fund, the surplus being retained by the Institute to be awarded to any one who may in future solve the same problem in regard to the infra-red rays.

The Judges desire to reserve the right of witnessing one of the experiments if in their judgment they deem it desirable after learning the name of the applicant.

(Signed)

HUGO BILGRAM,
ARTHUR W. GOODSPEED,
GEORGE F. STRADLING.

Philadelphia, Pa., June 12, 1907.

To the President and Members, Franklin Institute:

The Committee of Judges, after learning the name of the applicant referred to in preceding report, has unanimously decided that any further experimental demonstration of the problem is unnecessary.

(Signed)

HUGO BILGRAM,
ARTHUR W. GOODSPEED,
GEORGE F. STRADLING.

Philadelphia, Pa., June 14, 1907.

APPENDIX C.

At the stated meeting of the Franklin Institute held Wednesday, June 19, 1907, the following resolution of the Board of Managers was reported, viz.:

> "*Resolved,* That the Board of Managers hereby recommends to the Institute the approval of the report of the Judges upon certification from the Judges that they consider any further experimental demonstrations unnecessary." (A certification to this effect, signed by all the Judges, was found appended to the Judges' report.)

A motion was thereupon unanimously passed, confirming the award as recommended by the Judges and endorsed by the Board of Managers at its stated meeting held Wednesday, June 12, 1907.

WM. H. WAHL, *Secretary.*

Section of Physics and Chemistry.

(*Stated Meeting held Thursday, October* 11, 1906.)

A Résumé of the Literature of the N Rays, the N_1 Rays, the Physiological Rays and the Heavy Emission, With a Bibliography.*

George Flowers Stradling, Ph.D.

(*Continued from vol. clxiv, p. 74.*)

June, 1904.—Blondlot[42] takes up the thread of his work, saying that Becquerel's discovery of the brightening of the phosphorescent screen being due to the effect of the N rays on the eye and not on the screen shows why photography cannot be used to show the brightening of the screen. He contends, however, that the brightening of the electric spark is not due to the action of N rays on the retina, because the interposition of water causes no change in the appearance of the spark. The effect on a heated sheet of platinum is also unchanged by the interposition of water.

Blondlot[43] announced his discovery of a new property of matter, that of projecting spontaneously and continuously an emission subject to gravity and detected by its brightening a Ca S screen. A coin is held at any distance vertically over a screen. The latter grows brighter, provided both screen and coin are horizontal. If, however, the coin is beneath the screen and more than 6 cm. away the effect fails to appear. Copper, zinc, lead, wet cardboard acted as the coin did, while gold, platinum, glass, dry cardboard did not show the effect.

When the coin was put in a vertical plane the effect of brightening was found along two curves, one on each side of the coin. They seemed not to be parabolas.

*Numerals above the line refer to the numbers of papers in the bibliography at the end of this article.

The emission passes through a sheet of paper or cardboard and even a plank 2 cm. thick. A pane of glass stops it, by causing it to rebound.

A fortnight later Blondlot[45] states that a magnetic field deflects the jet of the ponderable emission, and that it appears to resemble an electric current. The original jet was separated by the magnetic field into three, one of which showed no electrical charge, the remaining two showing positive and negative charges respectively. The two jets acted on by the magnetic field were deflected by an electric field also, the directions of deviation in the two cases being consistent. The ponderable emission is carried along by air currents, and resembles the N rays in its action on the electric spark.

In a paper of the same date the same physicist[44] announces some small improvements in the photographic method of registering the effect of the N rays on the electric spark. He introduces an aluminium lens to concentrate the rays upon the spark.

Five papers appeared from the pen of Charpentier this month. He finds[80,94] additional reason for asserting that a Ca S screen, mounted upon an object which affects one of the senses, grows brighter when brought near a part of the brain especially connected with that sense.

One paper[93] is practically the same as that of one of the previous month.[79]

He finds that thermal sensibility is increased by the N rays and lessened by the N_1 rays. Put cold water in a test tube and pour hot water on top. Put the finger on the outer surface of the tube where the glass feels hot. The approach of a source of N rays makes the glass feel hotter. When the finger is in contact with a cold object the sensation is made more intense by the N rays. He thinks the N rays produce an increase of tactile discrimination.[95]

Since both sonorous and nervous vibrations act on the phosphorescent screen, they will produce a greater effect, if their periods are the same. Charpentier uses this to determine the frequency of nervous vibrations, finding it to be about 830[81,96] *per sec.*

Colson[104] continued his investigation of the production of N rays by chemical action.

Gutton,[108] who had previously investigated the effects of the magnetic field and of electric waves on the phosphorescent screen,

now contributes a paper bearing exclusively upon the N rays. A spectrum was formed of light from which the N rays had been removed. The violet end appeared brighter when N rays fell either upon the eye of the observer or upon the surface receiving the spectrum. This effect decreased from the violet toward the red end, disappearing at the red. Moreover the visible spectrum was prolonged toward the ultra-violet.

Becquerel[10] proceeds with his study of anæsthetics. He found that heating a body develops N_1 rays when expansion is produced, but N rays when contraction follows.[11] Prince Rupert drops emit N_1 rays parallel to the length, and N rays perpendicular to this direction. Alcohol has less effect on emission than chloroform.

He finds that both N and N_1 rays cease to act on the Ca S screen after they have passed through a magnetic field in a direction perpendicular to the lines of force. Passage along the lines of force makes no difference. He unearths analogies between the action of radium and of the N rays and concludes that the N and N_1 rays consist of an undulatory effect and of a material emission combined.[12]

Bichat[23] found that connecting to earth a source which is producing fluctuations of the brightness of a screen causes the variations to cease (vid. 143 and 166). N rays are obtainable merely by joining a metal plate to the earth.

Quartz held with its axis perpendicular to the screen causes brightening; when, however, the axis is parallel to the screen, the latter becomes darker.[24]

The opposite is true in the case of Iceland spar. This relation was found to hold for several positive and negative crystals.

E. Meyer and Lambert[128] found that N rays are emitted at the moment when blood coagulates.

Julien Meyer[131] states that, when a file as source of N rays is placed beneath a vessel of pure water above which a Ca S screen is held, the latter becomes less luminous. When the water is removed it grows brighter. From this he concludes that water emits N_1 rays under the action of N rays. Adding salt to the water is followed by the disappearance of the effect. Water has no reversing effect upon N_1 rays.

Three new contributors to N rays literature appeared in June, 1904.

Mercanton and Radzikowski[174] subjected the nerves of a frog to N rays but could discover no change in their electrical resistance, activity or rapidity of reflex action.

Rothé[137] develops a photographic method of studying the effect of the N and N_1 rays upon the phosphorescent screen. A circular patch of Ca S is put at a fixed distance from the photographic plate and exposure is made for five seconds. Then after twenty seconds a second exposure on a new part of the plate is made again for five seconds, and so on. The images so produced are not alike since the phosphorescent material emits less light as time passes. The diameters of the images were found to vary regularly with the time. When N rays acted upon the Ca S Rothé claims that the regularity disappeared owing to the screen becoming more luminous. His published data hardly seem to warrant this conclusion. It is also to be remembered that more than a month earlier Becquerel[8] had claimed to show that the N rays do not really increase the luminosity of the screen, the effect observed being due to the action of the rays upon the retina of the observer.

During the month of May criticism did not find its way into print. This was not the case in June.

Le Roux[169] states that there are apparent variations in brightness when a feebly illuminated surface is looked at in a darkened room. These variations he holds to be subjective. If a person looks at a Ca S screen it grows darker after half a minute. There comes a time when obscure clouds seem to pass across the luminous patch. Other people see oscillation of brightness. The initial aspect can be regained at any time by exposing the eye to white light, by coughing or by making noises.

The smelling of chloroform or ether reduces the brightness of the screen if the nostril on the side with the observing eye is used. The other eye is not affected. The inhalation of alcohol on the contrary produces a brightening of the screen.

Pacini[176] in Rome reported to Nature that he failed to get Blondlot's results.

The Revue Scientifique[199] threw out the warning, "It is to be feared that M. Charpentier has perceived only the variations of attention excited by the approach of a body or provoked by the suggestibility of the subject. The Academy of Sciences would do well to demand experimental demonstration. Radium has

made it easy to believe. Does not the effect of the N rays resemble that of magnets on hysterical subjects?" Doubt is again expressed a fortnight later.[200]

Burke[148] again reports failure in striving for Blondlot's results. He thinks expectation and concentration of attention are important factors in success. He could not detect the photographic registration of the effect of the N rays on the spark.

Baumhauer[144] failed to get any effect of the N rays upon a screen of Sidot's blende.

Salvioni[183] performed a lengthy series of experiments. "For several months I have dedicated myself with much constancy and little success to the phenomena recently described by Blondlot." He sought in vain for objective effects, using in turn the coherer and photoelectric methods of detection. When he turned to the phosphorescent screen he obtained some results similar to those of Blondlot. When he studied the foci behind a lens, the more carefully he worked the more of them he found until within a score of cm. there seemed to be 50 or 60 foci.

He holds that many of the results point to subjective causes, while on the other hand there are indications that along with the subjective there is something objective. In his opinion the phenomena of Blondlot have a singular resemblance to the pretended luminous phenomena of animal magnetism.

July, 1904.—This month witnessed the appearance in N ray literature of several well known names for the last time,—Becquerel, Bichat, Charpentier and J. Meyer.

Becquerel[13] claims that β rays cause a calcium sulphide screen to emit N rays. Polonium darkens the screen. He compares further the effects of β and N rays and of α and N_1 rays.

There is a difference, he finds,[14] between N rays from a Nernst lamp and those from tempered steel, Prince Rupert drops, compressed wood and Ca S previously exposed to the sunlight. Rays from the lamp are not affected by traversing a magnetic field perpendicular to the lines of force, while the other rays are changed in effect. He holds the N rays to consist of three kinds:

1. Such as are not deviated by the magnetic field and which do not act on Ca S.

2. Such as are deviated by the magnetic field and are much dispersed, like the β rays.

3. Such as are deviated in the opposite direction, as are the α rays.

The number of rays into which a beam of N rays is dispersed by the magnetic field varies with their source. He finds not only qualitative but even quantitative agreement between the effects of the magnetic field upon the N rays and upon the β rays.

In his final paper[15] Becquerel claims that the non-deviable rays are those which give the eight rays by refraction through an aluminium prism. When the N rays pass through air or copper they produce α rays perpendicular to their path, while under similar conditions N_1 rays produce β rays. He finds the nature and effects of the Blondlot rays to be more complex than does any other experimenter.

Bichat[25] found that the rays from a platinum wire, rendered incandescent by the current from a storage battery, after traversing aluminium make a Ca S screen brighter; while, if the electrical circuit is entirely insulated, the screen grows darker. Then joining any point of the circuit to the water pipes again causes brightening. Other curious effects of connection with the earth are described.

In the case of the heavy rays acted on by gravity they make the screen darker if their source is insulated. Joining the source to earth or electrifying the insulated observer causes an increased brightness.

When a person stands facing a wall Charpentier[82] finds that a Ca S screen shows positions of maximum and of minimum brightness when moved along from the body to the wall, indicating stationary waves of wave-length 3.5 mm. In one experiment 14 maxima were located in a distance of 52 cm. The wave-length is the same as that of waves in nerves determined by Charpentier by another method. In front of the eye the waves were only 2 mm. long. Other sources of N rays also gave standing waves in air.

In his closing paper Charpentier[97] discusses certain new forms of screens.

A careful statement of the conditions of success in N ray work is given by Le Roux.[120] He is very confident of his ground, saying: "I have been able to attain not merely to confirming the variations of brightness announced, but to seeing them under

conditions such that they cannot be tainted with any suspicion of subjectivity."

Blondlot[47] sets forth a new method of observing his rays. A longitudinal streak of Ca S is put on white paper and illuminated by orange light so regulated as to cause the bluish phosphorescent light to disappear. When N rays fall upon the calcium sulphide it becomes visible again. When the orange light barely permits the screen to be seen N_1 rays cause it to disappear.

He returns to his study of the heavy emission,[46] and announces that cleaning a piece of metal makes its emission cease. Heating it to 100° and letting it cool restores the property. No amount of cleaning seems able to stop the emission of lead, yet long exposure to the air brings it about.

All the liquids examined gave the heavy emission. The following are inactive: Platinum, iridium, palladium, gold and dry glass.

The heavy emission also received the attention of J. Meyer[132] in his final paper on the subject. Parts of the human body, he affirms, send out the heavy rays. He investigated the phenomena of transmission and absorption. When the hand is held over a funnel the emission collects in a bottle placed beneath, and can be poured out upon a screen which it causes to light up. It can be kept in an open bottle for several days. He concludes that different jets of this emission vary in speed.

Colson[105] is lead to announce certain conclusions concerning the constitution of dissolved salts from considerations based in part upon N ray effects.

Raoult[135] of Nancy reports his experiments confirming Charpentier's observations that the N rays increase acuteness of hearing while the N_1 rays produce the opposite effect.

Never at any time did the N ray investigators advance with more confidence or feel firmer ground beneath their feet than in this month of July, 1904, and yet their work ceased with remarkable abruptness. During August, September and October there appeared not a single paper recording investigation.

The Revue Scientifique [201,202] raised its voice in warning again. It criticized Charpentier's work in relation to the effect of the N and N_1 rays upon the sensation of temperature. He should not, it asserts, have made the tests upon himself but upon a

bandaged subject, kept ignorant of the approach and withdrawal of the alleged sources of the rays.

Later in the month in speaking of Salvioni's work[203] editorial comment was made upon those experimenters who "observe with a disconcerting facility properties more or less marvellous, whose origin ought to be sought much less in the N rays than in the depths of their subconsciousness, or in the action of badly interpreted natural phenomena."

During the months of August, September and October there was no lack of criticism. At the *Versammlung deutscher Naturforscher und Aerzte*[196] at Breslau in September a discussion on the N rays was held. Lummer and Rubens reported that they had obtained no results in repeating the most important of Blondlot's experiments. They failed to get the photographic effect with the spark. Blondlot sent some of his plates to Lummer, whereupon they tried once more and failed as before. They found that the brightness of a fluorescent screen changed in the ratio of 1 to 4 merely by moving the eye.

Paul Weiss, of Zurich, stated that he had noted changes in the brightness of the screen when moved over the nerves of the wrist, but that the changes were fitful. For three months, however, he had tried this and got the same topography of the nerves, even when he tried to get something different. He seemed to be of the opinion that the effects might be objective.

The discussion at the meeting of the British Association for the Advancement of Science[197] was very one-sided. Lummer reported the failure of Rubens and himself to get the results sought. Burke told that he had tried various persons but had found no evidence of external action upon the sight.

At the sixth International Congress of Physiology[198] at Brussels, Sept., 1904, Lambert, in discussing his researches on fermentation, came to speak of the N rays. The German members expressed their disapproval by absenting themselves at the time. At the close of this paper Henri stated that long and numerous experiments had been made on the N rays at the laboratory of physiology of the Sorbonne, but with no success. Pieron told of equally fruitless researches at the laboratory of physiology of the Hautes-Etudes. Then a series of physiologists from countries other than France rose and told of equal lack of success,—Querton of Brussels, Herzen of Lausanne, whose assistant went

in vain to Charpentier, and representatives of Italy, Russia and England.

Waller, the eminent physiologist of the nervous system, leaned toward one of his neighbors and said that the rays of Nancy should have been called the rays of suggestion, alluding to the studies in obscure mental phenomena made at that city.

Pieron asked Lambert to submit to the test of looking at the screen and telling when a source of N rays was brought near. The latter however excused himself on the ground of fatigue.

R. W. Wood,[193] of Johns Hopkins University, went to Nancy and spent three hours in the laboratory looking upon experiments with the N rays without seeing a single experiment succeed. He departed in the belief that those who had seen them had been deluded. It was arranged to have an observer tell when Prof. Wood put his hand in the path of the rays by noticing accompanying changes in a small spark, but in no case was the statement correct.

In the experiment of the spectrum produced by an aluminium prism, a beam 2 or 3 mm. wide was said to give after dispersion a band of about .1 mm. width. When the prism was covertly removed, the bands were located as before. Prof. Wood suggested that he place the prism while the N ray expert determine how it was turned. Incorrect answers were given in all of the three trials made. This failure was attributed to fatigue.

A steel file was brought up to the screen, but Prof. Wood could see no effect. He substituted a piece of wood for the file and others saw the changes as before. He suggests a repetition of the Pender-Cremieu collaboration as a good way of reaching the truth about the N rays.

Criticisms which he made upon the technique of photographing the spark under N ray influence will be considered elsewhere.

Blondlot[52] replied to Wood's criticism November 12th. He said Wood was warned that a person observing a phosphorescent screen could not necessarily tell when another person threw the N rays on the screen. "I affirm most positively," he says, "that the phenomena of N rays have for me the same certainty that other physical phenomena have. Several of my colleagues and a number of other persons say the same." He adds explicit directions for observing the N rays with the screen.

In October[205] the Revue Scientifique began an editorial discus-

sion of the status of the N rays. "Depuis le début des vacances, on ne parle plus en France de rayons N. Mais à l' étranger on continue à accumuler les expériences infructueuses, les resultats négatifs. Le doute ne cesse de croître."

"Il n' y a pas un pays étranger où les rayons N aient encore le moindre crédit et en France même on ne songe guère a discuter sur l' emission pesante * * * ni même sur la production de rayons par l' organisme."[206]

This periodical then obtained expressions of opinion upon the subject from many French scientists.[207,208,209,210,211,212,213,214]

The following believe in the N rays,—Bertholet, Pellat, Blondlot, Janet, Gariel, Lambert, H. Poincaré, D'Arsonval, Moreau, Swyngedauw, Girardet, H. Becquerel, Colson, Bichat, Gutton. These do not believe,—Langevin, Perrin, Monoyer, Brunhes, Lamotte, Cailletet, P. Weiss. The following failed to get results,—Pellat, Abraham, Perrin, Janet, Sagnac, Cailletet, Berget, Gouy, Monoyer, Meslin, Buisson, Camichel, Turpain, Weiss (Paris), Doumet. It will be noticed that in spite of this failure some of them believed in the existence of the disputed rays.

The attitude of Mascart is worthy of note. He expressed no opinion about the N rays, though Blondlot certainly believed that he, as well as Cailletet, was convinced, as is shown in a letter to the London Electrician.[51]

D'Arsonval also states that both Mascart and himself could distinguish effects upon the phosphorescent screen. More than a year later Mascart[123] appeared as the champion of the N rays, when nearly every one else had lost all belief in them.

Others who expressed no opinion are Bouty, Violle, Brillouin, Leduc, Moissan, P. Curie, Chappuis, Moissan.

Perrin, professor of chemical physics in the Sorbonne, is very emphatic in his opinion: "I think and repeat on every occasion for more than a year not only that there are no N rays, but that there is no objective phenomena capable of justifying the strange error of those physicists who have seen the rays."

Pellat, who expressed his belief in the existence of the rays, though he failed himself to get results with them, held that few can see them, and that the fortunate are rather the young and normal.

Cailletet says that he saw no results during his visit to Blond-

lot at Nancy, though there were many ladies present who saw the effects well.

Meslin went to Macé de Lepinay for assistance but did not feel much confidence in his experiments.

Buisson, assistant professor of physics at Marseilles, also saw little when the Marseilles investigator endeavored to show him the effects.

H. Poincaré was at Nancy but saw no effects that he was expected to see. This he attributes to involuntary accommodation of the eyes on his part. He believed in the reality of the photographic effect.

D'Arsonval stated that he had verified all the important facts, perceiving clearly the action of the nervous centers on the phosphorescent screen.

Weiss, Professor of Physics in the Faculty of Medicine, Paris, claims that Charpentier's determinations of the length of nerve-waves are wrong, and that this shows his N ray results to have a subjective element, because by his N ray method, he obtained about the same result as by his other incorrect method.

Colson stated that Blondlot and Wirtz saw just what he did in the case of the production of the rays by chemical means.

Very interesting is the statement of P. Weiss, Zurich. It was he who arose at the Breslau meeting and in face of the general sentiment against the existence of the N rays, stated that his experiments, though incomplete, seemed confirmatory. Now in the Revue Scientifique he reported that he was mistaken and that his results are negative.

L. Poincaré, inspector general of public instruction, could not see Blondlot's results.

The French journal Cosmos[237] speaks of the varying views about Blondlot's rays: "Ce mouvement d' incrédulité est parti d' Amérique, nous est arrivé par l'Angleterre et a gagné le Continent."

In spite of the bombardment of criticism during the latter half of 1904, there were a few who still continued to hold to the reality of the N rays.

Hooker[113] wrote another letter to the Lancet: "I take it that there are but few who do not acknowledge the existence of the 'n' rays." He presents an experiment to show that the results cannot be due to heat. The value of his observations is much

lessened by his subsequent statement that he carefully examined the "luminous ray spectrum, finding *inter alia* that rays emanating from a passionate man have a deep red hue; the one whose key-note in life is to be good and to do good throws off pink rays."

There is also another letter in the Lancet written by Niven[134b] expressing belief in the N rays.

Colson[106] continued his chemical investigations suggested by N ray effects previously obtained by him. A little more than a year later the Academy of Science bestowed upon him the La Caze prize for his general work in chemistry.

Breydel[60] advanced the theory that the N_1 rays are a vibrating impulse emanating from their source, while the N rays are a kind of movement of concentration converging toward their source. He also postulates the existence of another type of rays, the N_2 rays.

In the month of November Blondlot[48] published another paper relating to the photography of the spark when acted upon by N rays. This will be discussed later.

In December, 1904, the Leconte prize of 50,000 francs was awarded to Blondlot[236] by a committee of the Academy of Sciences consisting of Mascart, Troost, Darboux, Berthelot, M. Levy, H. Becquerel, Bouchard, Moissan, Janssen, de Lapparent and Poincaré. In their recital of Blondlot's scientific work but scant reference is made to his investigations of the N rays.

Before the year 1904 reached its close Bordier[59] presented in the Comptes Rendus a photographic method of showing the effect of the N rays on a phosphorescent screen. Becquerel[8] had contended that the rays produce no effect upon the brightness of the screen, a view with which Blondlot[42] subsequently agreed.

Bordier prepared two similar groups of patches of Ca S and exposed them to the light for some time. Each group was put upon a photographic plate. Upon one was laid a file to serve as a source of N rays. Upon the other was laid a piece of lead of equal weight. After twenty-four hours in the dark the plates were developed. Each patch of the phosphorescent substance was found to be surrounded by an aureole. The aureoles about the patches exposed to N rays were more extended than the others. A man, who was not acquainted with the design of

the experiment, measured the central images and the aureoles in both sets. His measurements showed a difference.

A fortnight after the publication of this paper the Revue Scientifique[215] states that the claim that the aureoles were larger about the patches exposed to N rays was not confirmed when a number of the members of the Institute examined the plates, and directs attention to the possibility of electrical phenomena, occurring in the course of the experiment, leaving traces on the sensitive plate. Besides this Le Bon has shown that the photographic plate is unequally acted on by different metals.

Weiss and Bull[192] reported a fruitless search for a direct effect of the N rays upon a photographic plate. A sheet of paper uniformly illuminated was photographed. N rays fell upon the plate at two places. On development these showed no difference from the rest of the plate.

Apropos of Bordier's experiment, Chanoz and Perrigot[150] reported early in January, 1905, the results of their examination into the conditions necessary for the production of aureoles on the photographic plate by Ca S. They found

1. A very brief time only is needed to produce aureoles.

2. The size of the aureole varies with the thickness of the layer of Ca S.

3. The size of the aureole depends upon the distance of the Ca S from the plate.

4. When two identical screens of Ca S are put under equal weights at the same instant on the photographic plate the aureoles are the same no matter of what material the weights are made.

During 1904 Kotnik[115] and also Bechterew[6] suggested that N rays may explain thought transferrence. According to the former the language centers emit N rays which excite the corresponding centers of the person on whom they fall and evoke auditory images.

Since the beginning of 1905 it is only after long intervals that experimental papers dealing with the Blondlot rays appear. The last paper by the discoverer of the N rays appeared in August, 1905.[53] In connection with this it may be well to take a general view of the work done in registering photographically the effect of the N rays upon a small electric spark.

As early as May, 1903,[28] Blondlot reported the existence of a difference between the images produced upon photographic plates

by the light of the spark when N rays fell upon it and when they did not. In Feb., 1904,[38] he furnished details of a more accurate method. A stream of small electric sparks illuminates from above a horizontal ground glass plate. Below this and parallel to it is exposed a photographic plate. A cardboard box having the plate for its bottom covers both the spark and the glass plate. Above this box is a lead plate covered with wet paper. This plate is fixed in position with respect to the photographic plate, and thus both must be shifted together. A beam of N rays comes vertically downwards. When the screen of lead is in their path the uninfluenced spark casts its image on the ground glass and from this an image is produced on the photographic plate. Next the lead screen is shifted from the path of the rays and with it goes the portion of the sensitive plate already acted on. A fresh part of the plate is now under the ground glass which is illuminated by the spark upon which the N rays now fall. In carrying out the experiment the alternate arrangements lasted for five seconds. The lead plate was shifted to and fro several times, the times of exposure of both halves of the plate being the same. By means of guides the shifting was performed in darkness. Much care was taken to get the spark feeble as well as regular. About forty experiments were reported, using as sources of the N rays a Nernst lamp, compressed wood, tempered steel, etc. In but a single case were the images on the two parts of the plate alike.

A few months later[44] Blondlot describes certain improvements in his method, such as concentrating the N rays by an aluminium lens and giving regular form to the terminals between which the spark passes. A few days after this Burke[148] reported his failure to find a difference between the two parts of the plate, and suggested that the interposition of the lead screen to intercept the N rays might damp the spark.

Lummer stated at the meetings of the British Association for the Advancement of Science[197] and of the *Versammlung Deutscher Naturforscher und Aerzte*[196] that he himself and also Rubens had been unable to obtain this photographic effect. They were favored by Blondlot with some of his own plates, but failure continued to meet them.

Wood[193] estimated that at the time of his visit to Blondlot's laboratory the brilliancy of the spark fluctuated by as much as

25 per cent. In his opinion the unconscious bias of the person shifting the plate might give the advantage of longer time to the part of the plate exposed during the period of action of the N rays on the spark. In his reply to Wood's criticism, Blondlot[52] says that since the latter's visit he has used an apparatus which recorded automatically the times of exposure. In a total exposure of each side amounting to about fifty seconds, the difference between the two periods of exposure was not more than .5 seconds, and moreover the benefit of the longer exposure was given to that part of the photographic plate used when the N rays were shut off. In spite of this, in every one of twelve experiments there was a larger image obtained when the rays had access to the spark.

Blondlot[48] in a paper appearing in November, 1904, turns the flank of Burke's suggestion that the moving of the lead screen affected the spark by stating that he had performed the experiment with no N rays and had found no difference between the two images. The spark-gap was surrounded by a conductor joined to earth but the difference in the images persisted.

In Blondlot's latest paper[53] he adduces a series of thirty-five experiments in support of his contention. In twenty-three of these there was a very marked difference between the two images, and in all a difference was visible. He claims that the application of improved methods have only made the obtaining of the effect more certain. He further says that more than 100 photographic experiments have been made by Jean Becquerel with constant success.

Even if it be granted that a new and objective effect has thus been obtained, let it be noted that it in no way argues for the existence of the N rays with their varied and surprising properties. All the evidence for their kinship to light waves was obtained by subjective methods, chiefly by the use of the calcium sulphide screen.

In the course of the year 1905 four experimental investigations told against the Blondlot rays. Guilleminot[158] permitted N rays from the Nernst lamp and from tempered steel to fall upon a selenium cell, either alone or accompanied by light, but in neither case could he detect any change in the resistance of the cell due to the rays.

Pozdena[179] made a very painstaking investigation of the

effects claimed for the heavy emission. His paper is a model of accurate work. In contrast with many of the French papers the greatest care was exercised to eliminate all suggestion and other subjective elements.

A silver gulden was the source of the alleged emission. One person moved the Ca S screen about in the space below the coin, another observer stated when the screen appeared brighter. A piece of lead could close an aperture below the coin thus cutting off any emission. There was total darkness throughout. Slight changes of sound made in moving the screen were avoided. When one position had been located in which the screen seemed brighter, it was noticed that the observer had a recollection of the position of his head and of the direction of sight. This tended to lead him to locate the position of brightness again where it was before. Moreover if the person in charge of the screen moved it rather more frequently over one spot a hint was given to the observer. To avoid these sources of suggestion the two persons changed positions after a spot of brightness had been found.

It was further noticed that the observer could tell by the sound whether the other wrote "o" for *offen* or "g" for *geshlossen* in recording whether the lead allowed the emission to pass or not.

Pozdena found no evidence whatever of the existence of a heavy emission. Only three times out of 150 settings did the phosphorescent screen come vertically under the coin, and in one of these few cases the lead was interposed.

In sixty-eight cases when the lead intervened the brightening of the screen was noticed as well as in eighty-two cases without the lead.

Stefanelli[185] found that the lessening of the brightness of the phosphorescent screen under the bell-jar of an air pump, which is caused by exhaustion, is really due, not to the emission of N_1 rays as J. Meyer[129] supposed, but to the fall of temperature of the enclosed air. Bellia[145] failed to get photographic effects.

The number for Jan. 15, 1906, of the Comptes Rendus contains two papers in support of the existence of the N rays. Mascart[123] describes a series of experiments in which a narrow Ca S screen mounted on the carrier of a dividing engine was moved through the space behind an aluminium prism which was intended to disperse the N rays derived from a Nernst lamp. The carrier

was moved until the screen lighted up presumably because it was in the path of one of the refracted rays. The corresponding reading of the position of the carrier was made. The screen was moved through the same extent of field by each of the four observers who in turn located the position of brightness. The following gives the readings of the settings for four positions of brightness:

Blondlot	Gutton	Virtz	Mascart
382.4	Not observed	381.	383.4
Not observed	387.2	386.9	387.
391.5	393.	392.	391.
398.4	399.	398.2	397.

Another series of settings was made by each observer in which the carrier was moved forward so as to set the screen in turn upon each bright band, then the motion was reversed and the settings were made as the carrier came back.

The series which follows was made by Blondlot:

Going	387.5	382.3	374.	368.2	360.2	358.	353.2
Returning	386.1	381.2	374.3	368.2	360.2	358.2	353.2

Gutton was not so successful in obtaining concordant settings. In one case the two readings for the same band differ by 4, when the distance between two adjacent bands is only 6 or 7.

But few details of this experiments are given in the paper.

The Revue Scientifique[216] subjects the above experiments to criticism. It directs attention to the fact that the readings of Virtz and of Mascart for the first band differ by 2.4, and in view of the entire field examined being only 16 in length, it concludes that "The precision is not really excessive."

In the experiments made by setting on the bands of brightness both going and returning it found that the space in which no bands were found was considerably less than the space in which bands were located.

The periodical suggests that as Blondlot made the experiments first the other experimenters may have unconsciously copied him. "Could not muscular memory account for the agreement of the settings made going and returning?"

Moreover, Blondlot had agreed with Becquerel that the apparent effect of the N rays upon the phosphorescent screen is in fact due to the rays producing an effect upon the retina. In spite of

this, how could Blondlot be consistent in taking part in the experiments described by Mascart?

Perrin[177] directs objections against the experiment from theoretical considerations.

Turpain[190] took up the going and returning experiments. He found that if he gave 10 impulses to the driving mechanism of the carrier of the dividing engine, then took the reading, gave 10 more impulses, took the reading, and so proceeded, he obtained the following series:

Going	4.58	9.65	14.26	18.58
Returning	4.54	9.61	14.95	18.51

There was no setting upon anything. The agreement follows from there having been the same number of equal impulsions.

Turpain seems to have made his investigations very carefully. He says: "For more than a year, except for short interruptions, I have pursued the observation of the N rays." His results while using the Ca S screen were concordant so long as he knew whether the rays were present or not, but became discordant when he was in ignorance. He often found a suppression of the N rays to lead not to a decrease but to an increase of brightness.

Experimenting with the Nernst lamp, files, the electric field, the magnetic field, the electromagnetic field, the Hertzian field, out of 962 trials the presence of the rays was detected in 783 cases, or 81%, when he knew what to expect. On the other hand the percentage fell to about 50 when he was not informed.

An interesting incident connected with Turpain's paper was its rejection by the Academy of Sciences.[220]

(*To be concluded.*)

(Stated Meeting held Thursday, May 2d, 1906.)

A Recent Development in the Chemistry of Cellulose.

By Dr. William H. Walker,

Professor of Industrial Chemistry, Massachusetts Institute of Technology, Boston.

Of the numberless bodies which now make up that department of chemical science which treats of the compounds of carbon comparatively few belong to the class to the consideration of which was originally applied the name "organic chemistry." In the early days of Wöhler, only those substances which occur organized in nature and which are formed in the animal and vegetable kingdoms only under the influence of a special, obscure agency called the vital force, were included in this classification. Among the few bodies which have hitherto resisted synthesis and which are as yet made only through the intervention of a vital force, are those which form the skeleton or framework of all vegetable tissues, and which are included under the generic term "cellulose." All plants, from the microscopic unicellular bacterium up to the giant conifers of the Yosemite Valley, are built up of cells, the envelopes or walls of which consist essentially of this organic compound, cellulose. From the earliest times, cellulose in its various forms has constituted the most important raw material used by man, either in its substantially pure state, as cotton or linen, or where it is associated with other more or less complex bodies in wood, bamboo, straw and other structures built up by the plant. For many years the commercial value of cellulose depended entirely upon its physical properties and the form in which it was obtained. When it became possible to modify the natural properties of this material by chemical treatment, its enormous economic importance was still further increased and its commercial value enhanced.

While the word "cellulose" may be used to include bodies of analogous composition having similar functions, it must not be

taken as signifying a simple, definite substance of unvarying properties. Just as we have wheat starch, potato starch and corn starch, varying in size and shape of granule, in viscosity and adhesiveness of the product made therefrom, etc., so, too, we have different forms of cellulose. Physically, these substances are, when freed from adhering waxes, resins and other incrusting materials, colorless, amorphous bodies capable of withstanding relatively high temperatures and soluble in none of the ordinary solvents. An ultimate analysis reveals the fact that cellulose is composed of carbon, hydrogen and oxygen in the proportions represented by the empirical formula $C_6H_{10}O_5$. This statement in no way, however, represents the true molecular complexity of the substance. Starch is represented by the same molecular proportion $C_6H_{10}O_5$. Superimposed upon what is probably a very complicated molecule in both of these substances, is what we call the colloidal state, a condition of matter of which we at present know almost nothing. In contradistinction to the sugars, the third closely allied member of the so-called carbohydrate group, we have in cellulose no clearly defined chemical or physical constants, such as melting point, boiling point, solubility relations, etc., to guide us. Although, as we shall find, the chemical reagents which act upon cellulose are not few, this action, unfortunately, is always accompanied by a more or less complete breaking down or splitting of the so-called cellulose aggregate. Through a study of those derivatives of cellulose and starch known as the bioses, where two $C_6H_{10}O_5$ groups combine with one molecule of water, Skraup, by means of a chlorine-acetyl compound, arrives at the conclusion that the simplest possible molecular weight of cellulose is 5508, while starch is 7440. This much, at least, is certain—that the forms of cellulose of which we have knowledge, are combinations of a large number of groups having the three elements in the proportion expressed by the formula $C_6H_{10}O_5$, and that, when undergoing chemical reaction, the more perfectly this complex or aggregate can be kept intact, the more valuable from a commercial point of view, are the resultant products.

A reaction which is common to all three members of the group of compounds, known as carbohydrates, viz., sugars, starches and cellulose, but which these substances show to a very unequal degree, is that of hydrolysis by dilute mineral acids. The sugars and starches are converted into bodies having an increased

percentage of hydrogen and oxygen, with the greatest ease, forming dextrose and levulose in the first case, and in the second a mixture of dextrose and other sugars. The enzyme diastase is also able to effect transformations of this character very easily. When we come to cellulose, however, we find a marked difference in the ease with which analogous reactions are brought about. Treatments which effect complete hydrolysis in the case of starch, has little or no effect upon cellulose. A different set of conditions are necessary to break up the cellulose aggregate and to add on the water necessary to form these simpler molecules or molecular complexes.

The earliest worker in this field to carry on systematic investigation and to obtain tangible results, seems to have been a Frenchman, Girard,* in 1881. By subjecting cellulose to the action of dilute sulphuric acid for several hours he obtained an easily pulverized mass, which he called cellulose hydrate and which he thought had the formula $(C_6H_{10}O_5)_2 . H_2O$. A few years ago Stern† repeated this work and failed to get the results described by Girard. He found, however, that if cellulose be boiled with 5% sulphuric acid, a part is converted into dextrose while the major portion is simply disintegrated. This disintegration is due to the fact that certain portions of the cellulose fibre are more easily attacked than others, and as these portions are dissolved their removal causes the structure as a whole to fall to pieces. Since Stearn did not follow, in any case, the directions of Girard, it is not surprising that comparable results were not obtained. The fact remains that the product of such acid treatment shows physical properties not possessed by the original cellulose.

This hydrolysis may be carried to the point where practically a complete conversion of the cellulose into soluble and for a large part also fermentable sugars, takes place. On this fact is based the much-talked-of process for obtaining alcohol from wood, of Classen and others, where dextrose is first formed and then subsequently fermented.

A relatively large number of processes for making hydrocellulose, differing in detail from the above, have been proposed, but they all result in a very friable powder in which the original

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*Ann. de Chem. et Phys., 24, 350.

†Jour. Chem. Soc., 85, 336.

structural form of the cellulose is lost. They all seem to bear out the general formula $(C_6H_{10}O_5)n. H_2O$.

One of the more common methods used by investigators in the field of organic chemistry for determining the number of hydroxyl groups in a compound, is to substitute each one by an acetic acid radical, making a so-called ester. This esterification is usually effected by treating the hydroxyl-containing substance with acetyl chloride or acetic anhydride, with or without the presence of some condensing or esterifying agent, such as sodium acetate, zinc chloride or sulphuric acid. By separating the products of this reaction and then subjecting them to treatment with alcoholic potash, the acetyl groups may be split off and measured, and the number of hydroxyl groups determined.

A. N. P. Franchimont,* in 1882, while studying the problem of the constitution of cellulose, used this method. He found, however, that if the cellulose be treated with acetic anhydride without a condensing agent, the conditions necessery for the reaction were such that an almost complete disintegration of the cellulose aggregate resulted. However, by adding sulphuric acid to the reaction mixture, a hydrocellulose was formed and the esterification then took place with great ease. He points out that esters differing widely in solubility can be produced by varying the proportion of sulphuric acid. It is thus seen that Franchimont was the pioneer in this field of cellulose chemistry and opened up the way for the great amount of work which has recently been done upon this subject.

Lederer,** in his method for the production of the acetic acid esters of cellulose, provides for making hydrocellulose according to the method of Girard, and subsequently esterifying by acetic acid in the presence of a small quantity of sulphuric acid. Miles,† repeating the method of Franchimont, places the sulphuric acid in the reacting mixture and makes the hydrocellulose at the same time that the acetylation is effected. H. S. Mork,‡ working in conjunction with A. D. Little and the writer, found that by using the sulphonic acids of phenol or naphthol, the reaction is more

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*Rec. trav. chim. Pays-Bas., *18*, 472.

**U. S. Patent, 654,988.

†U. S. Patent, 733,729.

‡U. S. Patent, 709,922.

easily controlled and a more uniform product obtained. Other investigators have proposed phosphoric acid, methyl sulphate and a variety of other hydrolyzing and condensing agents, without obtaining a materially different product. In all these cases, as in the original method of Franchimont, the resultant ester is dissolved by the reaction mixture and is recovered by precipitation therefrom in a large volume of water. The product of this procedure has been described as tetracetate of cellulose, and its appearance depends upon the way it is precipitated by water from its solution in acid. When saponified in the regular way with alcoholic potash, the product gives values corresponding to the tetracetate, although the yield corresponds to that of the tri-acetate calculated on the $C_6H_{10}O_5$ basis. Thus, 100 grams of carefully prepared cotton roving yields when acetylated with benzol-sulphonic acid, 168 grams of product, while that calculated for the tri-acetate is 177 grams and of the tetracetate considerably more. The saponification number is found to be about 705, while that calculated for the tri-acetate is 583 and that for the tetracetate 700.

Much light has been thrown upon this apparent discrepancy by a recent paper by Dr. H. Ost,* in which the analysis of these acetyl derivatives is discussed at length. Data are given which show that when the esters described above are saponified in the ordinary manner with alcoholic potash solution, acids other than acetic are formed, which, united with the potash, give an abnormally high saponification number. If the products of this saponifying action be mixed with sulphuric acid and the acetic acid distilled with steam, an amount of acid agreeing closely with that calculated for the tri-acetate is obtained. A method proposed by H. E. Perkin for determining the acetic groups in phenols was found by Ost to be especially applicable to the analysis of these products. It consists in gently heating the ester with 50% sulphuric acid solution for twenty-four hours or more, and then separating the acetic acid thus set free by distillation with steam. The figures obtained agree very closely with those calculated for cellulose tri-acetate, notwithstanding the fact that the products investigated were made by a number of different processes. The so-called cellulose tetracetate of Cross and Bevan, made by treating the cellulose recovered from the sulpho-carbonate reaction with

*Zeitschr. f. Angewandte Chem., *19*—993.

magnesium acetate and acetyl chloride, was examined by this method by Perkin and Greene and found to be in reality the tri-acetate. Of course, it is possible that these products consist of a mixture of di- and tetracetates in such a proportion that the saponification equivalent is that of the tri-acetate, but while there are indications that di-acetates do exist in the mixture, the above supposition is quite improbable.

The fact noted by Franchimont that acetates of very different solubilities could be obtained by varying the amount of sulphuric acid employed in the reaction also lead to the development of a number of new cellulose derivatives.

There are unquestionably two separate reactions taking place simultaneously, the first being the production of the hydrocellulose by means of the acid, and the second the formation of the ester of this hydrocellulose by the acetic anhydride, accelerated by the presence of another acid or its equivalent. Taking up first the preparation of hydrocellulose, we find that the method proposed by Girard was to soak the well purified cellulose in a 3% sulphuric acid solution until saturated, press tightly between filterpapers and dry in the air. The paper thus treated was heated in a closed flask to 70° for three hours. The resultant product was a brittle, white mass which reduced Fehling solution slightly and was more deeply colored with fuchsin solution than before the treatment. Mork, in repeating this work, found the method very difficult to control, and very sensitive as regards the pressure on the cotton before drying, and the temperature and time of heating. By using too much acid or heating too long, a product is obtained which is probably the highly degraded cellubiose of Skraup $(C_6H_{10}O_5)_2 . H_2O$. Lederer has varied the method of Girard by substituting acetic acid for water, but obtained the same brittle mass, which soon fell to a structureless powder.

A very much more valuable product of uniform quality, as shown by Mork, can be prepared as follows: Into a mixture of 400 parts glacial acetate acid and 20 parts benzol-sulphonic acid are placed 100 parts of high-grade bleached cotton roving. This is allowed to remain until perfectly saturated with the liquid, when the mass is pressed until one-half of the liquid originally used has been recovered. The wet cotton, now holding 200 parts acetic acid and 10 parts benzol-sulphonic acid, is allowed to

stand at room temperature ($15°$ to $20°$ C.) for about twelve hours. At the end of this period it will be found to have been converted into a highly reactive modification or form of cellulose which retains the original fibrous structure of the organic cellulose. When washed and dried the product is found to have increased in weight about 1.88% on the weight of the cotton used. This corresponds to the formula $(C_6H_{10}O_5)_6 . H_2O$, which would require an increase in weight of 1.85%. This process admits of perfect control and produces a hydrocellulose in which the original cellulose has suffered little, if any degradation.

In the recent publication already referred to, Ost confirms these results, although he gives as the optimum conditions a somewhat greater proportion of acid to the cotton, and allows the mixture to stand for two days. From data obtained by the ultimate analysis of his product, Ost arrives, quite independently of Mork, at the same empirical formula $(C_6H_{10}O_5)_6 . H_2O$. He confirms Mork's observations also, that too energetic treatment leads to a disintegration of the cellulose aggregate, forming products of much lower molecular weight containing a relatively larger quantity of water of hydrolysis.

All of these hydrocelluloses in the presence of the condensing agent react with ease with acetic anhydride, giving results which depend upon the extent of the hydration, the temperature of reaction and the time. Products may be made which are soluble in water alone, alcohol and water, acetone and water, acetone alone and chloroform alone. In obtaining the results given in the following table, cotton was treated with the hydrolyzing agent and acetic acid for the time given in the first column, and, without washing, was acted upon with acetic anhydride. The relative solubilities appear in the other columns, where *i* means insoluble, *ps* partially soluble, *g* gelatinized, and *s* soluble.

Cross and Bevan* have investigated an analogous series of substances and conclude that these compounds are the mixed esters of sulphuric acid and acetic acid. When a large amount of sulphuric acid calculated on the weight of the cotton was used, a material which was soluble in water was obtained, which contained the proportion of one sulphuric acid group for each $C_6H_{10}O_5$ group. By decreasing the amount of sulphuric acid the

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*Ber., 38, 38 and 1859.

% Benzene Sulphonic Acid (on cellulose)	Time (Preliminary)	Temperature of Acetylation	Time of Acetylation	Solubility				
				Water	Ethyl Alcohol and Water	Acetone	Acetone and Water	Chloroform
1%—2%	None	80°—100°C.	1—2 hrs.			i.		s.
10%	24 hrs.	20°C.	24 hrs.			i.	s.	p. s.
			72 hrs.			i.	s.	s.
25%	24 hrs.	20°C.	24 hrs.			p. s.	s.	i.
			72 hrs.			p. s.	p. s.	p. s.
			96 hrs.			p. s.		s.
			168 hrs.			p. s.		s.
50%	24 hrs.	10°—15°C.	2 hrs	s.				
			15 hrs.	g.				
			48 hrs.	i.		s.		i.
50%	24 hrs.	5°—10°C.	96 hrs.		s.	s.	s.	i.

product was no longer soluble in water but was soluble in aqueous acetone and contained less sulphuric acid and more acetic acid groups. When a relatively small amount of sulphuric acid was present, the more normal acetone- and chloroform-soluble acetates were obtained. So far as I know, the analytical results given by the authors in support of these statements have not been confirmed by others, but the fact that by increasing the amount of sulphuric acid, products of radically different solubility may be obtained, confirms the work of Franchimont and Mork.

The technically valuable acetic acid ester of cellulose, however, is the tri-acetate, although as generally made, some di-acetate is present. The tri-acetate is easily soluble in chloroform while the di-acetate is much less so, being scarcely gelatinized. The increasing solubility in chloroform, due to the change of di- into the tri-acetate as the reaction proceeds, is shown in the following experiments:

Hydrocellulose made as above described was treated with acetic anhydride at 40° C., giving the following data:

Time	Solubility in Reacting Acids.	Solubility in Chloroform.
30 min.	Soluble	Insoluble
1½ hr.	"	Slightly soluble
4½ hr.	"	Very soluble

It will be noted that all of the acetic acid esters of cellulose, in contradistinction to the nitric acid esters, have been heretofore produced by methods which have involved, as a necessary consequence of their successful application, the complete breakdown and destruction of the physical form of the cellulose structure concerned in the reaction; that is, the product of the reaction is soluble in the reacting mixture. The great practical disadvantages incident to this simultaneous solution will be apparent. Among them may be mentioned the difficulty of control; the danger of local overheating which makes necessary the working of small batches; the necessity of precipitation in water to check the reaction; and the dilution, and to a considerable extent loss, of the reagents employed. It has been the goal of investigators in this field to produce an acetic acid ester of cellulose which will retain the structural form of the original cellulose in a way analogous to that of cellulose nitrate. This has been successfully done by H. S. Mork in the following manner:

100 parts hydrocellulose is prepared as has already been out-

lined, and while still moist with the hydrolyzing acid, is placed in a mixture of 300 parts acetic anhydride and 1200 parts benzol and allowed to stand at room temperature (15° to 20° C.) for about eighteen hours. When the reaction is complete, as ascertained by removing some of the product and determining its solubility in chloroform, acetone, or other appropriate solvents for the particular ester toward the manufacture of which the process has been directed, the mass is freed as far as possible from liquid, by whizzing in a hydro-extractor, and is then washed and dried. Among the important advantages offered by this process may be enumerated the complete control which results from the moderation of the rate of esterification by reason of the low temperature at which the same is conducted, coupled with the influence of the benzol, or its equivalent, in restraining the reaction; the ease of testing the progress of the process and of stopping it at any time desired; the large quantities of material which may be handled without endangering the quality of the product, and finally the ease of washing and drying the product in bulk.

The analysis of this product shows it to be the tri-acetate of cellulose, but differing from an analogous fibrous acetate which has been prepared by Strehlenert and Reubold,* in that it has apparently preserved the large molecular aggregate of the original cellulose. The material itself shows greater strength than the acetate of Strehlenert (which is described as being brittle); gives more viscous solutions than acetates hitherto prepared, and is so far as can be determined a superior product in all its properties.

The uses to which cellulose acetate may be put are at present limited by the expense of the material itself, incident to the cost of the necessary reagents and the relatively high price of its solvents. In general, it may be said that cellulose acetate can find technical application most readily where nitrocellulose, on account of its inflammability and low temperature of decomposition, cannot be employed. At present its most important use is in the electrical insulation of very fine wire, for which it has found an extended application in the hands of the General Electric Company at Lynn, Mass. A highly desirable quality of artificial silk and artificial horsehair can be made from the acetate, but for the present it is ruled out of the market by its cost of production.

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*U. S. Patent, No. 812.c98.

Mining and Metallurgical Section.

(Stated Meeting held Thursday, May 9th, 1907.)

Black Sands of the Pacific Coast.

By Dr. David T. Day.

When any new country enters the list of civilized nations, its mineral deposits are greatly sought and it begins the age of bounteous mineral yield and consequent profligate waste. It is common to use only the richest deposits, and, of these, frequently only the richest parts.

It is a case of sudden access to riches with the usual squandering which has no regard for economy and no care for posterity's interests.

In the case of the United States we were slow to recognize our supremacy in mineral wealth over the rest of the civilized world.

For the first three hundred years and more we merely harvested the obvious gold in the placers of the Southern States and satisfied our needs for household utensils from the iron of Pennsylvania and New England.

The California gold rush of 1849 and '50, however, changed our mineral industry for all time and made keen the search for hidden treasure, everywhere. It brought out the ignorant fortune seekers who cared more for unearthing something hidden than for the development of legitimate industry. This greed of the ignorant has pursued precious metal mining to the detriment of the industry to the present day.

When in 1859 the development of petroleum in Pennsylvania furnished a flood of light to turn night into day we became a nation of *readers*. Before that none but the clergy read at night. Our great industrial advance was due fundamentally to the fact that nowhere in the world did it cost so little to read at night as in the United States, and this is still true.

With the resulting flood of information, the mineral requirements for great industrial developments exceeded all anticipation. Discovery of new and rich mineral deposits kept up with the demand. The State and National Geological Surveys taught people where to find new deposits and how to mine them with speed rather than economy. Our development increased so fast that with coal (for example), the production of any ten years has equalled the total production of all previous years since the industry began.

Of course no country's mineral resources are so boundless as to stand this depletion for any great length of time. Already the days of the anthracite coal trade have been numbered by the statisticians, and experts from France and Germany have been sent by their Governments to predict the end of our Lake copper and iron ores.

While these experts have returned obliged to confess the greatness of these deposits, it is significant that the trade this year in seeking a greater output of iron ore from the Lakes is not so exacting as to quality. In Pennsylvania the days of anthracite are being lengthened by washing the valuable coal from the old culm banks and by increasing the percentage extracted by every practicable means.

The day of gleaning only from our richest treasures is *past*, and already we are turning to deposits heretofore neglected because of impurities rendering them hard to work, or because of their low grade.

The concentration of low grade ores of all kinds is fast becoming an important feature of the mining industry.

Ores of precious metals have naturally received first consideration, and it is nothing extraordinary to see a hundred mechanical concentrating tables washing the ore of a single set of mines.

In older countries such economies are more common. But in spite of this the supply of one metal, platinum, has become alarmingly small. We are accustomed to import it from Russia, but the yield of the placer deposits in the Urals has declined sharply in the last few years, and pressure was brought upon Congress to have the Geological Survey search for it in the United States. We had already studied out its haunts and knew that it was not a problem of seeking new sources of

supply, but rather a matter of finding means of gleaning it cheaply from the waste of certain placer gold mines,—placers which came from certain great ridges of serpentine in California and Oregon, in which grains of platinum have been found here and there, but too sparsely to afford profitable mining in the original rock. It was necessary to seek it where the decay of such rock had left the platinum and other heavy materials richer by the washing away of the lighter ingredients.

The Geological Survey (which had pointed out the conditions for finding and utilizing our rich stores of wealth) was thus called to teach the art of saving by-products to men who were accustomed to staking everything in the chance of finding hidden treasure and who had thrown away, with contempt, everything but gold.

First it was necessary to analyse these sands and ascertain what they contained of value.

The definition of what is a useful mineral depends upon the times. Trade to-day demands various rare minerals which were merely cabinet curios a few years ago. There is nothing in those sands with the exception of platinum which is not already obtainable somewhere else, and the question of making these minerals useful depends upon the cost of separating them from valueless constituents.

First, a word as to the source of black sands.

When a placer miner washes down a gravel bank, all of the sand heavier than ordinary quartz collects in the bottom of his sluice box, together with the gold which he is trying to save. These heavy minerals are collectively known as "black sands." Perhaps the miner only "sluices" his gravel without the help of a hydraulic giant.

As soon as sufficient "black sand" collects in the sluice box to fill the riffles level full, these riffles no longer catch the gold and the operation must be stopped until the riffles are cleaned out, the gold panned out and the "black sand" thrown away. If the sands contain from thirty to fifty per cent. of "black sand," as is sometimes the case, the suspension of mining in order to clean out the riffles is necessary so frequently as to render the mining profitless, even when the sand is quite rich in gold. By this means small quantities of "black sand" are

continually being thrown away, and yet in the aggregate the amount is large.

The sands of the Pacific seashore have been washed so free from light sand by the action of the waves that practically all of the seashore sand is known as "black sand," and has accordingly a bad reputation, especially as the gold in these seashore sands is found in proverbially fine-grained sand, frequently as fine as ordinary flour. Further, the gold grains in the "black sands" are frequently so coated as to give difficulty in amalgamating and therefore it is particularly difficult to extract this seashore gold.

It has been the habit for many years in the West to throw away thousands of tons annually of these black sands without any effort even to determine the proportion of gold and platinum which they contain, because, even when quite rich, no practical method of obtaining the gold has been available. Hundreds of processes have been attempted for this purpose and abandoned.

When the Geological Survey was appealed to to study the principles governing the occurrence of platinum in the United States, we first collected some 2,000 samples of these "black sands" by inviting the placer miners of the United States to send in for examination samples of the heavy minerals found in their sluice boxes. The results of these investigations were of unusual interest. Among some thirty minerals found in these sands, the following are most frequent, mentioned in the order of their frequency of occurrence: Magnetite, gold, ilmenite, garnet, zircon, hematite and chromite.

It soon became evident that the element zirconium and the element titanium in the form of the minerals zircon and ilmenite, could be obtained in any desired quantity from these sands; that supplies of monazite, perhaps greater and more easily availed of than those already known, are to be had at small cost from these sands, and that occasionally platinum and chrome iron ore can also be extracted from them at the same time, and at low cost.

The method of analysis varied of course to some extent with the complexity of the sand, but in general we found it simplest and most efficient to pass the sand dry, and well screened, over a Wetherill magnetic separator. With the machine used by

us, a current of 0.2 of an ampere developed sufficiently strong magnetic force to extract all of the magnetic iron ore. Increasing the current strength to 0.8 of an ampere, and passing the sand through the machine again, all the chrome iron ore and ilmenite were extracted. A current of 1¼ amperes in this powerful machine was sufficient to extract all of the garnet, and by successively raising the current strength, the magnetization was sufficiently raised to extract olivine and hypersthene, and finally, at a current of 3½ amperes, monazite was extracted.

In this there is nothing new, as this has been the process for the extraction of monazite in Western North Carolina. Left behind were gold, pyrite, zircon, quartz, and several other non-magnetic minerals. As to platinum, nearly all of the grains were magnetic at one current strength or another, and left behind as absolutely non-magnetic was only the iridosmine, which frequently made up half of the mixture of platinum metals.

For further separation of such minerals as were left together in this magnetic separation, such as ilmenite and chromite, separation by a static electric machine, such as the Blake-Morscher, proved particularly easy, so that the combination of these two electric processes will probably be sufficient for the separation of these sands as far as experimental work is concerned, and where the sands are sufficiently concentrated, it is probable that such a combination would be efficient for commercial work, but in the condition in which these sands are obtained from the placer miners, some different and cheaper method is essential.

The greatest need for the "black sand" industry was cheap machinery by which the precious metals, platinum and gold, and if possible, also the other valuable materials, such as monazite, zircon and chrome iron ore, could be cheaply extracted with the platinum and gold. For this purpose the Survey invited makers of concentrating machines to send them for exhibition at the Portland Exposition and to operate them on the "black sands," as a field for friendly competition. The fortunate responses to this invitation included various mechanical shaking tables, such as Wilfley, Pinder, Woodbury and Christonsen tables, all of which proved able to effect the desired sepa-

ration. These tables consisted in a surface covered with linoleum on which were tacked many very small, narrow strips of wood to form riffles. Over this flowed the water, carrying the sand just as in sluice boxes, and the sand was caught in the riffles and without some additional factor, there would obviously have been no gain over the previous separation in the sluice boxes from which these sands had been taken. But in addition a shaking motion, or rather a blow, is given to the side of the table tending to throw the heavier materials to one side. The efficiency with which the platinum and gold were separated by such tables is almost beyond belief, and sands which had been absolutely refractory gave up their platinum and gold even when it was so fine as to serve as paint without further grinding. As much as ten to twenty tons per day could be worked on one of these machines and it was possible to carry on the extractions on a commercial scale. Twenty-five samples, each containing all of a whole carload were examined, and hundreds of smaller samples, many several tons in size. While it was impossible within the limited time to examine all the "black sand" localities in the West, still over 1,000 localities were examined and the principal useful minerals separated from those of no market value.

The results show these "black sands" to be a rich field for supplies of various rare minerals now becoming useful. Boise Basin, in Idaho, proved rich in monazite. Nearly every sand examined contained sufficient zircon to make this an object. Chrome iron ore can be obtained in any desired quantity, and by the concentrating apparatus it can be produced in a greater state of purity than any chrome iron ore now sold on the market. As to the uses for this chrome iron ore, any one can study this interesting subject right here in Philadelphia, where the Kalion Chemical Company manufacture potassium and sodium, bichromates for electric batteries, calico dyeing and other industries. The monazite industry has been developed in our midst as nowhere else in the world. It is now obtained from North Carolina and brought to Gloucester, New Jersey, where Dr. Waldron Shapleigh, with chemical skill which has never been equalled, developed methods for its decomposition and for extracting thorium from it on a commercial scale. Since his unfortunate death the work has been carried

on most efficiently, and the chemical process still further developed by the exceptional ingenuity and efficient skill of your Dr. H. S. Miner. This work has even led to the discovery of new elements, among the by-products obtained from these decompositions of monazite and zircon.

Another mineral which was found in practically every sand examined was ilmenite, the oxide of iron and titanium. Until lately this mineral has had the most unfortunately bad reputation among metallurgists. Its presence to any great extent in an iron ore deposit rendered the ore so refractory that we know of many deposits of rich iron ore condemned on account of the presence of this objectionable element. It leads to the formation of salamanders, that is, infusible masses, in the blast furnace. While many blast furnace misfortunes have doubtless been erroneously charged against the presence of titanium in the ore, there is no question but what it has proved a nuisance to the iron master. It is a significant fact that within the last few months this almost useless metal, heretofore only used to give a yellowish tint to porcelain in the manufacture of artificial teeth, has now come to have much commercial value for furnishing titanium chloride as a mordaunt for the calico printer. Further, other uses in connection with electric lighting have lately been found for mixtures of magnetite and ilmenite, so that altogether ilmenite must in the future be reckoned as a useful mineral and lose its reputation as a metallurgical nuisance. Enough has been said to indicate that in the treatment of our "black sands" one must give attention to the by-products which can be obtained together with the precious metals.

As to these precious metals themselves, naturally gold is most important as to metal value, and the yellow metal will always rank highest in popularity with the miner.

It needs no lecture to furnish inducement to the placer miner to save the gold to the last possible extent, but on the other hand, it is an astonishing fact that enough *platinum* has been thrown away annually in placer gold mining in the West to more than supply all the needs of the United States. To be sure, the amount of this platinum thrown away at any one place is particularly small, amounting usually to one-tenth or

less of the gold which is also thrown away, due to its intimate mixture with the grains of "black sand," and the difficulty of separating it therefrom. But this platinum is an essential in many industries. It is a metal of which we must have a certain quantity, even when a large demand and lack of supply sends the cost temporarily to over $40 an ounce, as has been the case within the last year.

Within the short space of four years the element platinum has taken on an entirely new significance as an industrial metal. This can be concisely expressed by the fact that its price has increased practically ten-fold in that time. If we consider for a moment this change in the position of platinum relative to other metals, it will develop clearly the important characteristic of this element and its kin-folk. The remarkable change in the price has included a human element of great significance, and one which we shall consider first in order to dispose of it. Let us consider, therefore, as more interesting to this audience (although not more significant perhaps in its effect upon the metal) the features in the price fluctuations in this metal due to human agencies. It should be recognized that the association of dealers in platinum, including the French Platinum Society, the firm of Hereaus in Hanau, Germany, Johnson & Mathey, in England, and one or two other smelters of platinum, have undertaken to assume charge of the destinies of platinum, and temporarily at least, have placed its statistical position where it never would have been without their connivance. This association is generally supposed to have the support of several other concerns, more or less prominently connected with the distribution of platinum to the various industries that consume it. For several years there has been apprehension of a platinum famine. The reasons for this apprehension are variously stated by diverse interests. On the one hand the plausible statement is made that during the Russian-Japanese war the miners in the Urals were pressed into military service, with none to take their place in the platinum mines, and later the internal disturbances in Russia, have been equally disastrous to the platinum production. This argument is combatted by rival interests, who maintain that the production has not diminished in Russia, but that the platinum merchants have assumed control and have hoarded the supply. For example,

I have talked with scientific gentlemen who have seen an amount of platinum hoarded in Hanau very much in excess of the stock naturally required by the owning concern. It is argued further that the demand for platinum has largely extended, but no one is ready to point out the cause of such extension except the natural growth of the industries to which platinum is incidental. It seems to the speaker that the great and sudden changes can only be explained by adding the two causes together, and still the sudden jump in value is almost marvelous.

Platinum production has always been essentially a placer mining matter, and it is only natural to expect quick exhaustion of the most profitable ground and increasing scarcity of the product. It is a marvel that Russia has kept up its production as well as it has, and we must recognize a minor benefit to mankind from the manifestly barbarous practice of consigning political prisoners to exile in Siberia, where they furnish the cheap labor for platinum mining. Apparently the placer deposits which have yielded platinum in the Ural Mountains of Russia have at last become so impoverished that the determination is evident among platinum users to look elsewhere over the world for future supplies. In this quest South America has been turned to again and again in the hope of utilizing the placer deposits of the West Coast. The supply there is evidently second only to Russia in the amount of platinum which could be furnished. Each time, however, development of these deposits has been repelled by malarial fever and by governmental interference, and after attention to platinum in Australasia the seekers have now turned determinedly to the West Coast of the United States. Our two years' experience in investigating this region leads to the belief that for practical purposes our West Coast must be considered as the most favorable hunting ground of the future for the platinum metals, and we hope also that the deposits of copper and iron sulphides in which platinum and palladium have been found lately in the course of the extraction of other metals, will yield a supply of platinum for the distant future when our placers have followed the course of Russia and become poorer more rapidly than the facilities for extraction shall have increased.

A glance at a map will show where platinum is found in the West and why.

Let us then consider the conditions of occurrence of platinum in California and Oregon. We should remember that practically the first mention of platinum in the United States was by Blake, who first found it as almost a fine powder in the fine heavy sands of the Pacific Beach in the neighborhood of Port Orford, near the mouth of Rogue River, Oregon. Blake made quite a study of the platinum, and found that it was usually about one-tenth as common as gold on the various beaches, and the proportion of platinum with gold was found to be greater going farther north along the beach into Coos County. Not long after this Silliman investigated the heavy sands in Butte County, California, especially near the village of Cherokee. He noted platinum and its associated metals, iridium and osmium, and this village of Cherokee has remained a classic spot for the study of platinum and its allies in black sands. Later studies by various authorities have revealed platinum in many localities in Del Norte, Humboldt, Siskiyou and Trinity Counties in California, and directly joining these counties in Oregon platinum is found to a very marked extent in Josephine and Jackson Counties as well as in Curry and Coos Counties already referred to. In order to make anything like a complete picture of the occurrence of platinum in the West, we must think also of the Pacific beaches in Washington, and of a very remarkable platinum locality near the head waters of the Similkameen River, B. C. Platinum, together with josephinite, is quite plentiful on the head waters of the Fraser River, particularly near Lilloeet, in British Columbia. In the southern part of California, the shores of Monterey Bay, and the southern part of San Luis Obispo County and of Santa Barbara County are also significant platinum localities. In connection with the locality already referred to in Butte County, it should be noted that platinum has been traced northward to the northwestern corner of Plumas County, and southward as far as Marysville, in Butte County. If, therefore, we think of one very large locality comprising the four southwestern counties of Oregon and extending south to include the four northwestern counties of California, and with a detached deposit in Butte and Plumas Counties and another in Mon-

terey, San Luis Obispo and Santa Barbara Counties, still another stretch along the Washington beach, and another in Southern British Columbia, we can fix in our minds the principal hunting ground of the future for this precious metal, lately priced at twice the value of gold. To be at all complete, we must point to minor localities in California; along the Snake River near its mouth, in Idaho, sporadic occurrences in Montana, and unexplored suggestions of large deposits in southeastern and southwestern Utah. In the effort at completeness we must also call attention to some gravels in the neighborhood of Baltimore, Maryland, and to the fact that platinum has been discovered minerallogically in North Carolina; in a glacial drift on Lake Champlain, and that commercial quantities have been found in Sudbury, Canada, and a deposit much like this Sudbury material also gives commercial promise southwest of Laramie, Wyoming.

Before we confuse ourselves with these minor occurrences, it is well to fix our attention on the California and Oregon main fields by a glance at the geological map of California. These maps show, by certain numbers, the principal rocks noted in different localities. The more we study this map the more evident it will become that the placer mines containing platinum are rich in so-called black sands. These black sands are for all practical intents and purposes a mixture of chromite (as the most *significant* factor), together with magnetite, ilmenite, and a few other heavy minerals. The practically universal occurrence of chromite in such of the placers as yield platinum enables us to trace this heavy sand back practically every time to large masses of serpentine. This serpentine, you will notice, particularly characterizes the coast range by remarkable persistent series of large masses extending north and south through the counties of California and Oregon where we have already noted platinum as being plentiful. I wish to bring out particularly clearly not only the fact that platinum is allied with these particular basic magnesian rocks, but that the platinum sand washed from these sands is peculiarly characterized. Practically always it carries iridium and osmium. Usually these two elements in the form of iridosmium form a considerable percentage of the entire amount of platinum metals. Occasionally they exceed the platinum in frequency. Palladium

is infrequent. Ruthenium, be it remarked, is a characteristic of the platinum found in one locality, Josephine County, Oregon. It would be easy to state the region of a given specimen of platinum sand, if this ruthenium is noted in it. The sand in other respects, however, is like the mixture of platinum metals found elsewhere throughout this region. It is well at this point to leave the Pacific Coast for a moment in order to contrast this occurrence with those in Sudbury, Canada, and the analogous deposit in the Rambler copper mines, and the also analogous occurrence of platinum in copper ores in southwestern Utah. In the Rambler mine iridosmium is as yet unknown. Palladium and platinum prevail, and so far not in metallic state, but as arsenides. Further, where the platinum and palladium thus occur as arsenides in deposits of sulphide of iron and copper, the associated rocks are not olivine and its derivatives, but vary so greatly among themselves as to bear no simple relation to the occurrence of platinum in them.

The most frequent heavy mineral in these "black sands" is magnetic iron ore; this not only almost everywhere, but the percentage is frequently high. In eighty samples taken from the Pacific beaches, from San Diego in Southern California, to Cape Flattery, Washington, the magnetic iron ore averaged twelve per cent. Naturally, our sands were usually concentrates, and this is not intended as an average for the whole coast. Still, several samples showed forty per cent. of magnetic iron, and four car-loads from the mouth of the Columbia River contained thirty-three per cent. Similarly, the sand at the mouth of Gray's Harbor, Washington, was unusually rich in magnetic iron. In fact, a dozen or more places were found where the iron ore could be separated in pure form at a total cost on board barges in still water for less than $1.00 per ton and containing over sixty-five per cent. metallic iron.

It should be recalled that your own authority, John Birkinbine, for years the honored president of this Institute, pointed out years ago this important source of iron for the Pacific States.

Lest some objection might be made to the quality of this iron ore, it should be pointed out that with the coöperation of the Portland General Electric Company, this iron ore was smelted in the ordinary arc electric furnace of the Heroult type and satisfac-

tory pig iron made, which showed unusual toughness, due to one-half per cent. titanium which it contained.

From what has been said, surely you will recognize that the time has come in many branches of our mineral industry where, instead of simply using our richest mineral deposits until they are exhausted, we are already supplementing them by enriching humbler low grade materials and making them equally efficient. And in the concentration process it will be well always to keep a watchful eye for useful by-products.

The great gain in this new era of concentrating processes rests not alone upon the fact of adding greatly to our available mineral wealth, but most essentially in the beneficial change of our mining industry from the pursuit of hidden treasure to the encouragement of mechanical and chemical advance in applying waste materials to the benefit of humanity.

MEASUREMENT OF ICE-BOUND STREAMS.

The laws governing the flow of rivers that are frozen over have recently been investigated by members of the United States Geological Survey. A paper, entitled "Determination of Stream Flow During the Frozen Season," by Messrs. H. K. Barrows and R. E. Horton, has been published in which the effort is made to formulate methods for estimating the flow under such conditions, and important recommendations as to methods are made.

Estimates of the flow of rivers are made in all parts of the country. To a great extent these are based on daily gage readings and numerous current-meter measurements. In the northern and central parts of the United States the streams may be closed by a more or less permanent ice cover for a considerable portion of the year. This period varies from nearly five months in the extreme north to a few weeks or less in the Central and Atlantic States. The methods in use for estimating flow under open-channel conditions have become well defined, and the limits of accuracy are known to be reasonable. On the other hand, the study of the flow of streams under ice cover is but just started, and in order to systematize the accumulation of data and to provide the material in convenient form for future use it is desirable that certain general methods be followed.

As estimates of flow, to be of conclusive value on streams utilized for water power, must embrace these winter periods of low water, it is easy to see the importance of this inquiry.

According to a U. S. consular report, thorianite, one of the rare minerals, has been discovered in a riverbed of Ceylon. Quantities of the mineral have been mined, and have sold at $8500 per ton.

THE CEMENT INDUSTRY IN 1906.

The following statement, issued by the United States Geological Survey, shows the approximate production of hydraulic cements in the United States for the calendar year 1906.

This statement is exact within a small fraction of one per cent. and is issued in advance of the annual report on the production of cement which is now being prepared in that Bureau. The returns on which it is based are complete with the exception of those from four small plants.

The total production of all kinds of hydraulic cement in 1906, including Portland, natural-rock and Puzzolan cements, was 50,027,321 barrels, valued at $54,015,713.

Of the above total amount of cement manufactured in the United States in 1906, 45,610,822 barrels were Portland cement, with a value of $51,240,652; 3,935,275 barrels were natural-rock cement, with a value of $2,362,140; and 481,224 barrels were Puzzolan cement, valued at $412,921.

Prices were good in 1906, and showed an advance over those of 1905. The total production of cement in 1905 was 40,894,308 barrels, valued at $36,012,189. Comparison of totals for 1905 and 1906 shows an increase in 1906 of 9,133,013 in production and $18,003,524 in value.

QUARRYING ICE IN SWITZERLAND.

The introduction of electric railroads into Alpine districts has been the means of establishing a new industry—namely, the quarrying of glacier ice for distribution in large cities. It would appear that certain of the Swiss communes have been able to grant concessions of their glaciers for this purpose, and considerable sums have been expended in constructing ice slides or V-shaped troughs, in which the blocks of ice, often of large size, blasted out of the glacier, are transported to the vicinity of the stations for conveyance in carefully refrigerated cars to Lyons and other large cities remote from the Alps. The method of blasting with black powder so as to avoid the discoloration and soiling of the ice, and the engineering ability displayed in erecting the slides and in providing sufficient friction by means of curves to avoid excessive speed in the downward journey of the ice blocks, are spoken of as examples of considerable ingenuity and skill.—*Metal Worker, Plumber and Steam Filter.*

CLAYS OF THE ST. LOUIS, MISSOURI, DISTRICT.

In the year 1905 St. Louis produced and sold about $5,000,000 worth of clay products—approximately one-thirtieth of the entire output of the United States. A very large proportion of these were made from fire clays, dug in a single section within the city limits. A brief description of the clay resources of the St. Louis district, prepared by N. M. Fenneman, is included in the United States Geological Survey's "Conributions to Economic Geology, 1906" (Bulletin 314), just published and obtainable on application to the Director of the Survey, at Washington, D. C. The paper contains also references to available beds of shale and brick clay near the city and a map showing the locations of the fire-clay mines.

(Stated Meeting held Thursday, May 9th, 1907.)

The Goldfields District, Nevada.

(ABSTRACT.)

The new camp of Goldfields, in Nevada, was revisited in November of 1904 by Mr. J. E. Spurr, of the United States Geological Survey. This district lies about 23½ miles south of Tonopah, and was located late in the spring of 1903. Shortly after the discovery of gold in this district it was visited by Mr. Spurr. A little work was then in progress on what is now known as Columbia Mountain, but up to that time no good strikes had been made. In January and February, 1904, however, rich finds were made in certain spots south of Columbia Mountain. During the next year the district acquired an approximate population of 6,000. The town of Goldfields has sprung up, and a number of smaller adjacent camps have been established.

The district is bounded on the west in part by a lava-capped mesa, the erosion of which has laid bare the underlying gold-bearing rock. The auriferous region is characterized by numerous low, irregular ridges standing out from the lower and more nearly level surface. These ridges owe their origin to hard reefs of quartz which form their crests. Their resistance to erosion has left them protruding thus above the general elevation, and in these quartz reefs the auriferous deposits are found.

Columbia Mountain is the most prominent of these ridges, and some notes on its geology were made public by Mr. Spurr, in Bulletin 225, published by the United States Geological Survey. Near the south end of the ridge the rock is largely alaskite (an igneous rock consisting of quartz and feldspar), which is sometimes of granitic structure, and sometimes very fine-grained, even resembling quartzite. White mica or muscovite is sometimes present, and pure quartz veins of dikes, of similar origin, also occur. These alaskitic rocks are intrusive into a dark siliceous rock (jasperoid) which is probably the result of the silicification of an original limestone. We may suspect that this limestone was paleozoic, and that the alaskite is post-Jurassic. On the north end of the Mountain the

rock is a very much altered rhyolite; in this rhyolite are broad masses of white to purplish and reddish cherty quartz, which extend irregularly in a northerly direction. This quartz is simply a highly silicified rhyolite. The silicified areas have ill-defined walls, and the highly mineralized portions which they enclose are very irregular.

On his last visit Mr. Spurr took notes over an extended area, and made interesting additions to his knowledge of the geology of the district. The area of known ore bodies has spread so far beyond Columbia Mountain that values are now found over an area several miles square. The most productive area measures two to two and a-half miles in either direction. The chief mines at the present time are the Jumbo, the Combination, the January, and the Florence, all grouped together about a mile south of the southeast end of Columbia Mountain. Some nine miles southeast of Columbia Mountain is the Diamondfields group, including the Vernal, the Quartzite, and Black Butte, from which shipments have also been made. Other ore deposits have been developed in various parts of the field.

The rocks in that part of the field visited by Mr. Spurr on his last trip (the region of Columbia Mountain, Diamondfields, and the Jumbo group of mines) were found to be almost entirely volcanic, consisting of rhyolites, rhyolite tuffs, andesites and basalts, all probably of Tertiary age. The alaskite and jasperoid of Columbia Mountain are hardly represented in the surrounding district. The predominant rocks are abundant rhyolites and andesites, while basalt is rare. One andesite examined microscopically from near the Tonopah Club is a hornblende andesite, resembling the early andesite at Tonopah; a patch of basalt from near the Florence is an augite basalt, like the basalt of Siebert Mountain at Tonopah. The rhyolite resembles the rhyolite of the Gold Mountain district, which lies about four miles south of Tonopah, on the road between Tonopah and Goldfields; and this Gold Mountain rhyolite, again, resembles closely some of the phases of the earlier (dacitic) rhyolite at Tonopah. The relative age of the rocks at Goldfield has not been determined, but it probably corresponds to that of similar rocks at Tonopah.

At Goldfields the ores occur in both rhyolites and andesites, showing that mineralization occurred subsequent to the erup-

tion of both lavas. At Gold Mountain the deposition of the ores evidently followed the eruption of the rhyolites, and at Tonopah the eruption of the earlier (dacitic) rhyolites was succeeded by a period of mineralization which produced irregular veins that frequently carry a larger proportion of gold than the locally more important veins formed after the eruption of the early andesite. There is therefore the possibility that the Goldfields deposits are identical in origin with the later series of veins at Tonopah. Indeed there are at Tonopah, in one place at least, mineralized quartz reefs in rhyolite tuffs that have the same peculiar characteristics as the tuffs of the Goldfields reefs; and assays of these Tonopah deposits, as was known to Mr. Spurr two years ago, have shown a moderate amount of gold and no silver.

At Goldfields there are no definite veins. The outcrops of the quartz bodies are irregular, straggling, branching, and apt to disappear suddenly. Neither were any definite systems observed, though further study might reveal them. There seems, however, to be a tendency to elongation in a northerly direction. The outcrops may even be nearly circular, or crescentic, and frequently they are roughly lenticular and intermittent. The quartz itself is gray and jaspery; it is almost entirely due to the silicification of the volcanic rock in which it occurs. Practically no ordinary crystalline vein quartz was observed.

All indications show that this silicification (and the accompanying mineralization) is the work of hot springs, and that these irregular reefs represent the horizontal sections of columns of rocks traversed by rising columns of hot water. Had the rocks been strongly fractured we should have had veins, like those of the early andesite at Tonopah, which were also probably due to hot spring action; but at Goldfields the lack of such a fracture system resulted in this curious and rather unusual type of deposit. It follows that the quartz reefs will probably, as a rule, extend deeper vertically than horizontally, and so have roughly the nature of columns or pipes.

Although showing disseminated pyrite, the greater part of one of these jaspery quartz reefs contain little or no gold. Microscopic investigation has shown in one case that in such quartz the iron of the pyrite is probably mainly indigenous,—that is, that the iron sulphide has been formed by the action of

sulphur contained in the hot spring waters, upon the iron silicates contained in the hornblende and bietite. This explains the absence of gold, as the pyrite has the same origin as the barren pyrite near the ore bodies in the country rock at Tonopah. Within some of the barren reefs of silicified rock at Goldfields, however, prospecting has sometimes discovered portions containing gold, even in large quantities. Such portions are usually lenticular or irregular, like the main quartz reefs, and they are not easily distinguishable from the barren quartz, except by panning or assaying; but it seems probable that these sheets are the real ore deposits, and that the mass of the reefs constitutes merely a siliceous jacket or casing, such as is shown to surround ore bodies in some other parts of the world. While this siliceous casing may be twenty-five or thirty feet wide, the auriferous portion may be only one or two feet; and the form and extent of this portion become evident only after the ore has been extracted. It is then seen to have a definite channel-like shape, often more regular than that of the whole outcropping reef, though it has usually a limited extent in the direction of its greatest elongation. It seems probable that these pay shoots represent the main channels of hot-water circulation, while the siliceous casings are the result of the water soaking through the adjacent rock.

The ores are often of very high grade. As an extreme example may be noted a shipment of $14\frac{1}{4}$ tons from the Sandstorm (Kendall claim), which when worked in a stamp mill yielded $45,783 net, while the tailings still contained about $1,000 to the ton. From the McKane-Bowes lease on the Jumbo, $600,000 was taken out in five months, from a space of 100 feet horizontally and 200 feet vertically on the sheet. One small shipment of 917 pounds of ore from this lease gave gross returns of $4,766. The whole production of the camp has been from ore which may be roughly estimated as averaging $200 to $300 per ton, or more. The values are all in gold; silver is usually practically absent; although the shipping ore from the Combination mine contains from one to three ounces.

It is important to consider the origin of this rich ore in order to make prophecies for the future. Most of that which up to the present time has been extracted has been oxidized ore. The ores are mixed sulphides (usually pyrite) and oxides, clear up to the surface. The oxidized material, which follows cracks

and seams, is usually several times (sometimes several hundred times) as rich as the unoxidized portion. The irregular spongy nature of the free gold particles in such oxidized material completes the proof that this gold has been dissolved and redeposited in a concentrated form during the process of oxidation. Iron sulphate derived from oxidation of the pyrites is the probable agent. A peculiar yellow coating pointed out to Mr. Spurr as the best sign of values in the oxidized ores, was shown by Dr. Hillebrand to be a basic ferric-alkali sulphate, containing both sodium and potassium,—perhaps jarosite. Other sulphates, such as alum and gypsum, are abundant. These oxidized ores are prepared for shipment by screening, the fines being shipped and the coarse quartz rejected.

As the water level at Goldfields is usually high for this desert country (water having been encountered in several shafts at 130 to 200 feet) it is plain that this oxidized ore is only a temporary supply. In the Combination and the Florence, however, sulphide ores of very high grade have been found below the oxidized zone. In these mines a dark gray copper-bearing mineral, which is very rich, is most intimately connected with the gold. A specimen from the Combination, analyzed by Dr. Hillebrand, proves to be a sulpho-salt of copper, antimony, and arsenic, which, so far as qualitative composition goes, may be tetrahedrite. Tellurium is also present in this ore, and the same element has been reported elsewhere in the district. Therefore the sulphide ores also may be very rich. Moreover, while the difference between the oxidized and the unoxidized portions of the ores within the zone of oxidation is in general so great, certain sheets occur, as in the January and the Jumbo, where the unoxidized quartz in this zone is of extremely high grade. Such ore appears to be mostly pyrite, but in view of the fact that tellurium is found in the district, it is very possible that gold telluride may be present. It therefore appears probable that the rich oxidized ores owe their richness not primarily to concentration during oxidation (though this process has certainly been very important), but to the existence of rich antecedent (sulphide) ore.

Concerning the origin of these sulphides, it is probable that some, so far as can now be seen, are purely primary, while others have been formed subsequent to the main silicification of the reef, as in the Combination mine. Here the rich aurifer-

ous sulphides have formed in a broken zone (breccia-zone) in the silicified barren reef, and occur as seams, and often as coatings in the pebbles in the breccia. The question arises, however, as to whether the subsequent mineralization was the result of descending or ascending waters. Concerning this the evidence is not conclusive, but there is no sufficient evidence that these rich ores have been concentrated from the lean antecedent quartz mass. The presence of elements like arsenic, antimony, and tellurium in the subsequent sulphide ore suggests a deep-seated origin.

Besides the elements mentioned above, bismuth occurs in the ore. In the January it occurs in the oxidized ores in the form of silvery scales, which is, as determined by Dr. Hillebrand, bismuth, perhaps the oxide bismite. In the Combination long needle-like crystals have been found, which, according to the manager, Mr. Collins, give the chemical tests for bismuth sulphide, bismuthinite. The silvery mineral above noted is sometimes found, in the January, arranged in long rod-like forms, and these are probably pseudomorphs after the sulphide. In the January this silvery mineral is usually, but not always, an indication of rich ore. Barite is a common mineral in all these deposits, but is not abundant.

The indications are, therefore, not unfavorable to the continuance of high-grade, or at least good-grade ores, down to considerable depths. There is, however, as has been already demonstrated by exploitation, no continuous regularity to the ore shoots, whether sulphide or oxidized. They are curving, irregular, and often lenticular, but it may happen that below a shoot which has come to an end, another shoot may be found occupying a slightly different relative position, or even overlapping the first. Similarly, the main quartz masses as a whole can be expected to show little regularity in depth; they may increase in size, or diminish,—or even disappear, at least temporarily.

Erratum.

Art. Obholzer, Extract of Report on the Methods Used to Avoid Piping in Steel Ingots, &c., July, 1907. Page 6, line 1, *for* inches *read* feet.

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THE FRANKLIN INSTITUTE.

Southern Appalachian Streams.*

BY CHARLES E. WADDELL,

Consulting Engineer, Biltmore, N. C.

As the streams of the Southern Appalachians are destined to play an important role in the industrial development of the South, I deem a consideration of their characteristics and salient features of sufficient interest to merit your attention to-night.

From the days of the Colonies until the time of the Civil War the South was essentially an agricultural community and little or no manufacturing was done. Events subsequent to the Civil War have changed the conditions, and the South is becoming not only the leading producer in the three great crops of cotton, rice, and tobacco, but it is forging ahead along industrial lines. Not very long ago cotton was exported from the fields of Alabama and Georgia to the factories of New England. It is now generally recognized that the better practice is to finish the raw product where it is produced, hence the

*A lecture delivered before Franklin Institute, in the Hall of the Young Men's Christian Association, October 22d, 1906.

factories have moved to the cotton fields. One of the most potent influences in the creation of the industrial South has been the perfecting of methods of transmitting electrical power long distances, and the generation of this power from the numerous rivers. The pioneer work in this line was done at Anderson and Pelzer, South Carolina, about 1895; I believe that it was in these two places that hydro-electric plants were first used to drive cotton mills. The experiment was watched with deep interest, and the results achieved were a stimulus to general development and application.

To arrive at a clearer understanding of the prominent features of the streams under discussion, it is first necessary to consider the physiography of the region. The Atlantic seaboard in the Southern States presents three types of formation. First, the Coastal plain; further inland, the Alluvial belt, and still further the Appalachian range of mountains, and while this chain extends from Maine to Alabama, and is variously known as the White Mountains, the Adirondacks, the Alleghenies, and the Blue Ridge, it is with the Blue Ridge that we are concerned this evening.

To the south of the Shenandoah Valley, in Virginia, occupying portions of Virginia, North Carolina, South Carolina, Georgia, Tennessee, and Kentucky, lies a tableland more than three thousand feet above the sea level, seventy miles wide, and three hundred miles long, known as the Southern Appalachian plateau. All of the important streams south of the Ohio River, in the Mississippi, Gulf, and South Atlantic drainage, trace their source to this plateau. The physical feature that differentiates the Southern Appalachians from the rest of the system is the way the rivers rise. Northern rivers, such as the James and Susquehanna, rise on the most westerly ridge and break through the intervening ranges, wending their way to the ocean. The New River, rising on the slopes of Grandfather Mountain, in North Carolina, in the most easterly range, and flowing into the Ohio, is the first stream to violate this law, and establishes a precedent followed by all other Southern rivers, hence we find all streams flowing north, south, east and west rising on the slopes of the Blue Ridge.

The plateau is bounded on the east by the Blue Ridge and on the west by the Unaka range. The eastern slopes of the

Blue Ridge are gradual and form the Piedmont section, noted for its richness and agricultural value. The Unaka mountains, on the other hand, are higher, more rugged, and cut by the rivers into innumerable gorges. Lying between the two ranges are sundry irregular cross ridges, called the "Blacks," "Craggies," "Balsams," "Cowees," "Nantahalas," and "Smokies." Contained in these groups are 275 peaks over five thousand feet high, and thirty-six exceeding six thousand. Conspicuous among the last is Mount Mitchell, the highest peak east of the Mississippi, and the oldest land on the American continent. The mountains are clothed to their summits with forests of the finest hardwoods. The flora is of the richest and most beautiful, due no doubt to the copious rainfall.

The rainfall over the whole area averages fifty or more inches per annum, and in the vicinity of Highlands, N. C., reaches the extreme figure of seventy inches. With the exception of Puget Sound, this is the greatest precipitation in the United States.

This tract, embracing approximately 10,000 square miles, is the natural reservoir that supplies, replenishes, conserves, and tends to make uniform the flow of all the rivers.

Uniformity of flow depends largely on the nature of the soil, the character and extent of the country drained, the presence or absence of lakes, and the distribution of rainfall. In the South lakes and glacial deposits are entirely lacking, hence the streams depend solely on the rainfall. Fortunately this is greatest in summer and least in winter, for in summer the requirements of plant life and the increased evaporation demand more water than the other seasons.

The rivers emanating from this plateau in the course of their length present three distinct types. First, in the mountains they descend rapidly, are confined in narrow channels, and abound in falls and cascades, along which portion they are susceptible of hydraulic development in innumerable places; their value for power purposes is, however, curtailed by the limited drainage area. The second stage is through the Piedmont section, where the streams contain their finest water power and are themselves of great magnitude, for miles descend shoal after shoal. This is the portion usually designated as the "Fall Line." The final stage is below the Fall Line, where

they lose their dynamic force and become navigable bodies of water.

The pre-eminent apex of the drainage area in the Southern Appalachian Plateau is Grandfather Mountain, in North Carolina. It is the highest peak in the Blue Ridge, and to its slopes four great rivers—the New, Yadkin, Catawba, and Holston,—trace their source. The New River, to which allusion was previously made, rises on the northerly slopes, crosses the State of Virginia, and after its confluence with the Gauley, is known in West Virginia as the Kanawha. Its head waters comprise the counties of Ashe, Wautauga, and Allegheny in North Carolina. Its valley in the State of Virginia is famed for its beauty, and although the river possesses great fall, and its characteristics are well known, yet it is one of the least developed of the Southern streams. The proximity of the Virginia coal fields is doubtless accountable for this condition.

Considering the water courses in rotation, the next claiming attention is the Roanoke. This river is formed by the Dan and the Staunton at Clarkesville, Virginia, and while not strictly speaking a Southern Appalachian stream, it may be so classed, for although the Staunton does not drain the Southern Appalachian Mountains, the Roanake's course lies wholly in the territory so drained. Neither the Staunton nor the Dan have any marked fall. The Roanoke crosses the fall line at Weldon, North Carolina, draining at this point more than 9,000 square miles, and the fall in nine miles exceeds eighty-five feet. If properly supplemented with steam 75,000 horse power could be generated in this locality, although its value for power purposes is limited to a marked degree by the violent floods and extreme fluctuations to which it is subject. The flood flow is often sixty-one times the minimum, an unusual condition in a stream with so large a drainage area. The Roanoke Rapids Power Company have developed the river to some extent, and are furnishing power to a number of industries in the town of Roanoke Rapids.

The Cape Fear, the river next in succession, claims the distinction of being the only large river, together with its tributaries, that lies wholly in one State. Formed at Moncure by the junction of the Deep and Haw Rivers, the Cape Fear crosses the State in a southeasterly course and empties into the At-

lantic at Southport, a town thirty miles below Wilmington. This river gets its name from the noted Cape Fear, a point dreaded by mariners almost as much as Cape Hatteras. With the exception of the Susquehanna, this stream is subject to greater floods and lower stages than any other stream on the Atlantic seaboard. The river is navigable as far up as Fayetteville, and previous to the general extension of the railroads attempts were made to increase this distance. A few miles above the town the fall line is encountered, and for thirty miles the river descends a succession of shoals.

The river is developed at a number of points, the power in every instance being used to drive mills in the vicinity. There is, however, an hydro-electric plant of some magnitude being constructed at Buckhorn Falls, the history of which is of interest. In 1796, the State granted a charter to the Cape Fear Navigation Company to erect dams, build locks, and render the river navigable in this locality. $80,000 or $100,000 were spent and practically nothing accomplished. The work was continued at intervals, and after passing through countless vicissitudes, and spending $350,000, the project of navigation above Fayetteville was abandoned at the beginning of the Civil War. In part by natural causes, and in part intentionally, the works were destroyed. In 1868, the State appropriated the property to the Raleigh and Augusta Railroad Company. A little later it was bought by the Deep River Manufacturing Company, an interest largely controlled by the Lobdell Car Wheel Company of Wilmington, Delaware, who owned iron mines in the vicinity and were seeking water transportation. Between 1876 and 1880 boats were run occasionally, and since 1880 have ceased altogether. The difficulty throughout has been in getting the ends of the dams and the locks protected from freshets. The present owners, with the intention of developing electric power for transmission to Raleigh and Fayetteville, acquired the property in 1895. Lawsuits contesting the riparian rights, together with other unfortunate circumstances, have resulted in the complete tie-up of the property.

The Yadkin and Catawba, two rivers of prime importance, are next in order. A peculiar feature of these streams, and one common to numerous others, is that where they leave a

State, they change their names, thus the Yadkin and Catawba of North Carolina become in South Carolina the Great Pee Dee and the Wateree.

The Yadkin rises on the southern slopes of Grandfather Mountain, is in all some four hundred miles long and empties into the Atlantic at Georgetown, South Carolina. The fall line is crossed at Cheraw, about 150 miles from its mouth, above which point falls and shoals abound, the most prominent being Bluitt's Falls and the Famous Narrows. Both are being developed at present, the former by the North Carolina banking house of Hugh McRae & Company, who expect to secure about 15,000 horse power, and transmit to the milling town of Darlington; and the Narrows by the Whitney Reduction Company, a Pittsburg corporation. Probably the most striking hydrographic feature on any Southern stream is the Yadkin Narrows, the great river draining more than four thousand square miles of territory, and which in the vicinity of Salisbury, North Carolina, is nearly half a mile wide, at a point about twelve miles southeast of the town contracts to a width of one hundred feet, in places even narrowing to sixty feet, and for four miles roars and crashes in a gorge that it has worn down through the solid granite. The development contemplated consists of a dam some fifty feet high at the head of the rapids and a canal several miles long. Forty thousand horse power will be generated and will be transmitted at a potential of sixty thousand volts to the adjacent manufacturing towns.

Like Yadkin, the Catawba rises on the Blue Ridge, one of its principal tributaries, the Linville, traces its source to the southwestern slopes of Grandfather Mountain. The Catawba crosses the State line twenty miles south of Charlotte, below Columbia, together with the Congaree, it forms the Santee and empties into the ocean in the vicinity of Georgetown. The fall line is crossed at Camden, above which point an area of five thousand square miles is drained. From Camden to the foot of the mountains sixteen notable shoals are encountered. On ten of these developments are being projected at the present moment. The first hydro-electric plant built on this river was the Catawba Power Company's 10,000 horse power plant at Rock Hill, South Carolina. This property, with others, has been merged into a corporation known as the Southern Power

Fig. 2. Dam and canal of Southern Power Company's Great Falls plant, 30,000 horse power, Catawba river.

Company. With a paid-up capital of $10,000,000, the Southern Power Company enjoys the two-fold distinction of being one of the largest power companies in the country and of being built with Southern capital. An ultimate development of ten plants with an aggregate capacity of 132,000 horse power is planned. Of this amount 122,000 horse power will be obtained from the Catawba River alone. The fact that there is a market for so great an amount of power impresses an observer with the titanic proportions of the New Industrial South, and when it is realized that this is but one company and one river the scope of the entire possibilities is not easily grasped. The Piedmont section is the manufacturing district of the Carolinas, and it is the heart of this territory that is controlled by the hydro-electric plants of the Catawba and the Yadkin. In a radius of fifty miles of Charlotte a conservative estimate of the hydraulic developments contemplated or in process of construction would be a total capacity of not less than 250,000 horse power. The amount and price of the power, the railroad facilities, the character of the population, and the salubrity of the climate are fast making this particular section the great manufacturing center of the South, and a district which in time will rival Lowell, Holyoke and other New England centers, even as Birmingham is now rivaling Pittsburg in the iron market.

The limited time precludes consideration of all of the streams, and although the majority possess enormous undeveloped power, and many are developed to some extent, a discusion of the Broad, Toxaway, Saluda, Savannah, and others must be omitted, and your attention next directed to the Chattahoochee, conspicuous in this instance as it is the first of the Southern Appalachian streams to reach the Gulf. Rising in North Georgia, the river for the greater portion of its length forms the boundary line between Georgia and Alabama. The Atlanta Water Power Company's Morgan Falls plant, distant some thirty miles from Atlanta, is at present the largest development on the river, and furnishes the greater part of the power used in the City of Atlanta. The North Georgia Electric Company, at a cost of upwards of $7,500,000, propose to develop other powers on this river and also on its tributary, the Chestatee, and it is credibly reported that an immense de-

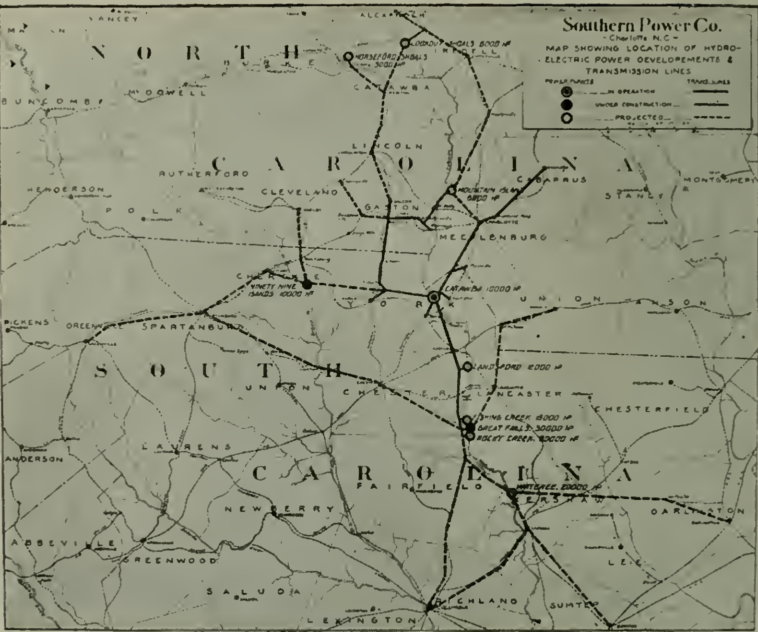

Fig. 3. Map of Southern Power Company's hydro electric plant and transmission lines.

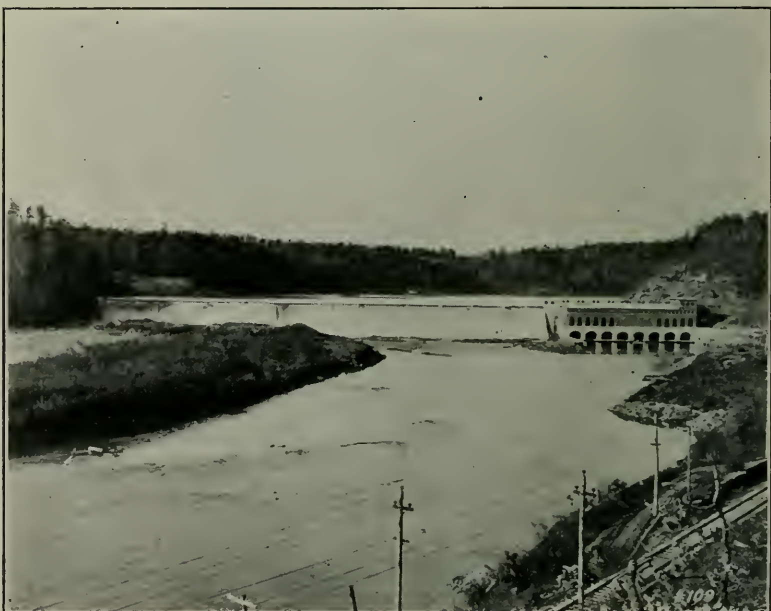

Fig. 4. Atlanta Water Power Company's Morgan Falls plant, Chattahoochee river, 10,500 kilowatts 48-foot head, 20,000 volt, 30-mile transmission.

velopment is shortly to be made at Columbus, Georgia, where one large plant now exists.

Passing to the western drainage system, the first prominent stream to claim attention is the Little Tennessee. Rising in Rabun Gap, in Georgia, it crosses Western North Carolina and cuts its way through the Smoky Mountains. A characteristic of all Western rivers is the deep canyons they have cut through the Unaka range. In some past age the hills have been rent asunder, and the streams have slowly but continuously worn away the stone cliffs. At the North Carolina-Tennessee State line the Little Tennessee drains an area of two thousand square miles and for a distance of four miles in North Carolina is a roaring torrent falling a total of 240 feet The river is comparable here with the Narrows of the Yadkin, and inferior only on account of the lesser drainage area and consequently the lesser amount of water. A development to the extent of 50,000 horse power is planned in North Carolina, which, taken with a projected development of 20,000 horse power a few miles across the State line, makes the river one of the most noteworthy power streams in the Western system.

Second in importance to the Little Tennessee is the French Broad. This stream rises in the Pisgah Forest, of the Biltmore Estate, and by reason of the protection the forests afford is freer from excessive floods and low minimum stages than any other stream. From Brevard to Asheville the fall is slight. A few miles north of the city the rapids begin and in a distance of forty miles the fall is seven hundred feet, while the area drained is about eighteen hundred square miles. Its value as a power stream is curtailed by the proximity of the railroad, which precludes the construction of high dams and limits developments to small units.

At this time there are but two hydro-electric plants in operation on the western rivers, one of these located at Asheville, on the French Broad, the other near Waynesville, on the Pigeon River.

A large hydro-electric plant is now under construction at Hale's Bar, on the Tennessee River, forty miles below the City of Chattanooga. The Tennessee River is formed a few miles from Knoxville, Tennessee, by the confluence of the French Broad and the Holston; at Chattanooga it counts as its tribu-

Fig. 5. Weaver Power Company's dam, French Broad river.

Fig. 6. Interior Weaver Power Company's plant, French Broad river.

taries the Holston, the Wautauga, the French Broad, the Big and Little Pigeon, the Little Tennessee, the Hiwassee, and a number of other smaller streams, including in fact the whole western drainage. Normally the river is navigable as far as Knoxville, although below Chattanooga pronounced shoals exist which interfere with navigation in certain seasons. The United States Engineers after years of study reported the most feasible method of improving the river would be the construction of a dam at Hale's Bar sufficiently high to back water to Chattanooga. Congress sanctioned the plan, and granted permission to individuals in Chattanooga to coöperate with the Government and to utilize the power so obtained for commercial purposes. It is anticipated that 50,000 horse power will be available, and the undertaking is a striking illustration of the excellent results that can be accomplished in improving our water ways where local interests and the Government work harmoniously.

This brief discussion would not be complete with a consideration of methods that will insure the future usefulness, and policies that will improve the streams of the Southern Appalachian plateau. Since nature has denied lakes it will be necessary to create artificial bodies of water. Lake Toxaway and Fairfield are examples of what may be accomplished at a reasonable cost, while primarily intended for pleasure resorts and to enhance the beauties of the Sapphire country they have incidentally proved to be most valuable in regulating the flow of the streams on which they are located. In the case of Lake Toxaway one inch of rainfall over its entire watershed will raise the level of the lake but ten inches, granting that all of the precipitation could immediately reach the lake, while with the confined limits of the overflow weir thirty or more days would be required to discharge this quantity of water.

Nature was lavish in her provisions of forests, but these are now being rapidly demolished, a fact that should be a matter of national regret. That the forests wield a potent influence on the flow of streams can be stated without fear of contradiction. Floods and low water seasons have always existed, and probably ever will, but it has been demonstrated beyond reasonable doubt that on streams where the head waters are protected by plant growth these conditions are reduced to a minimum.

The forests exert a fourfold influence on the streams; by the mechanical action of the trunks, limbs, and leaves, they break the fall of the raindrops; the roots keep the ground open and porous, thereby assisting percolation; the forest floor, consisting of the humus and debris, is from its hygroscopic nature a most excellent filter and preventative agent to the formation of rivulets and gullies, forcing the water to soak in and seek subterranean drainage; the cooler atmosphere of the forests appre-

Fig. 7. Ruthless destruction of timber in Western North Carolina.

ciably retards evaporation. This, however, is to a large extent offset by the amount of water required for transpiration when the trees are in leaf.

Since wood is more widely used by man than any one other material it would be ridiculous to assert that the forests must be protected to the exclusion of the lumbering industry, but it is not unreasonable to demand that the present crude and extravagant methods be superseded by more enlightened practices.

A greater menace, and more destructive than the lumber-

men are the annual forest fires, which kill the seedlings and undergrowth, destroy the floor, and preclude the possibility of the forest reproducing itself. Generally the fires may be attributed to carelessness, and only in the rarest instances is malice the cause.

The small agriculturalist is almost as serious a factor as either the lumberman or the fires. The mountain sides by reason of their steepness are unsuited to agriculture, and are abandoned after a few crops as the fertile soil has been washed away and erosion ensued.

It is erroneous to suppose that a primeval forest of gigantic growth is essential to the preservation of a stream. Any growth that meets the four requirements previously mentioned and excludes agriculture is all sufficient. In my opinion a low copse growth is to be preferred. Ere long it will be necessary to replant many districts, and the cost and most suitable trees will be the subject of much discussion. At present afforestation is conducted on the Biltmore Estate at the small cost of $15 an acre. The plantings are usually white pines, and a growth of marketable timber is anticipated in about twenty-five years.

The measure to establish a Southern Appalachian Forest Reserve now before Congress is most commendable, and is probably the only solution of the problem of preserving the forests, and incidentally the streams, for the National Government rather than the State can exercise a more far-reaching control, replant denuded tracts, and organize a system of fire protection. The rivers being interstate waterways, their protection should from the nature of the case be a national matter.

In conclusion it may be stated that the streams issuing from the Southern Appalachians are capable of being developed to the extent of 1,000,000 horse power, while 200,000 horse power would be an extreme figure for the amount now in actual use, and were it possible to market the entire power an annual income of $30,000,000 would be derived. On the plateau there falls each year sufficient rain to make a lake four feet deep over the entire States of Rhode Island, Delaware, and New Jersey. To conserve this rainfall and to develop the enormous powers are the problems with which the South is now deeply concerned.

PHOSPHORUS FROM WAVELLITE DEPOSIT AT HOLLY SPRINGS, PA.

Until recently phosphorus, which is used chiefly in the manufacture of matches, was made solely from bones and organic substances. Only since the perfection of the electric furnace have natural phosphates been used to any extent in making phosphorus. The extraction of phosphorus from mineral deposits has been investigated by the United States Geological Survey, and the forthcoming number of the annual "Economic Bulletin" will contain an article by George W. Stose on phosphorus ore at Holly Springs, Penna.

At the foot of the northern slope of South Mountain, in the vicinity of Mount Holly Springs, about ten miles southwest of Harrisburg, a deposit of wavellite occurs in the white clay associated with manganese and iron ores. Small quantities of phosphorus had previously been obtained from phosphorite and from apatite, but wavellite, which is aluminum phosphate, has never before been used commercially in the manufacture of phosphorus, as the mineral generally occurs in very limited quantities.

The American Phosphorus Company was organized by Philadelphia capital to develop the deposit and a mill was built nearby. The mine was opened in 1900, the first years being devoted to prospecting and experimenting with the reduction of the ore. During 1905 the mine was in active operation and 400 tons of ore were reported to have been extracted and reduced in the company's furnaces.

The different methods of manufacturing phosphorus are described. The Readman process, patented in 1889, is the one that has come into commercial use in most countries.

The world's production of phosphorus has been variously estimated to be from 1000 to 3000 tons a year. The greater part is made in the Albright & Wilson factory, Wednesfield (Oldbury), England, where the Readman process originated. Other large factories are located at Lyons, France, and at Griesheim and Frankfort, Germany. There is also a plant in Sweden, and there are numerous smaller ones in Russia.

The zinc smelters of Holland, Belgium, and the west of Germany receive their ore supplies through the ports of Hamburg, Rotterdam and Antwerp, but chiefly through Antwerp. These smelters have been for many years dependent upon foreign mines for nearly their entire supply of raw material. The system of receiving these supplies has therefore become well organized through long experience. This organization has made Antwerp the favorite port of entry. There are at that port convenient docks for unloading and trans-shipping the ores; agencies for the sampling of the ores as received; brokerage houses for the consummation of transactions in custom lots; and public assay offices for the determinative work that may be required. Antwerp is, moreover, conveniently situated with respect to the principal smelters of Holland, Belgium and the Rhine, has excellent railway connections, and also is the terminus of an extensive canal system, by which cheap transportation to the works can be secured.—*Eng. and Min. Jour.*

Section of Physics and Chemistry.

(Stated Meeting held Thursday, October 11, 1906.*)*

A Résumé of the Literature of the N Rays, the N_1 Rays, the Physiological Rays and the Heavy Emission, With a Bibliography.*

George Flowers Stradling, Ph.D.

(Concluded from vol. clxiv, p. 120.)

Let us return to the Comptes Rendus of Jan. 15, 1906. The second paper on the N rays is by Gutton.[109,110] Blondlot had found that when N rays fall upon the primary spark gap of a Hertzian oscillator the secondary spark becomes less bright. In the hands of Gutton this receives considerable development. He claims that the diminution of brightness of the secondary spark is very marked. Photography was used to obtain an impartial registration of this effect. The secondary spark illuminated a photographic plate for a minute, while the N rays fell on the primary spark. Another part of the plate was acted on by the spark when the N rays no longer reached the primary spark. After development the two images are found to be different. Precautions were taken to avoid any effect due to changes in the primary circuit or to unconscious bias in shifting the photographic plates. Every one of thirty-seven experiments showed a difference between the two images.

To this experiment the Revue Scientifique[216] objects that though the shifting of the plates was governed by a metronome, yet it was executed by hand and not mechanically. The secondary spark, less stable than the primary, accordingly evokes less confidence even than the primary spark did in Blondlot's photo-

*Numerals above the line refer to the numbers of papers in the bibliography at the end of this article.

graphic experiments. Besides, though all that Gutton claims be granted, no argument for the likeness of the cause of the effect to light waves can be drawn.

At the meeting of the French Physical Society on March 2, 1906, Cotton and Raveau[152] spoke upon Gutton's experiment. They went to Nancy to see the experiment and spent almost all of Feb. 24, 1906, in going over the experiment, using both the arrangement already published and also another not yet made public. At first they seemed to notice an effect of the N rays upon the secondary spark. When, however, they found that the removal of the source of N rays, a Nernst lamp, made no difference in the appearance of the spark, they were driven to hold that it must be the opaque screen, moved now into, now out of the supposed path of the N rays, which caused the effect. Cotton asked for a simple modification of the screen and was much surprised when both Gutton and Virtz opposed the change. When for the visiting physicists the experiments were performed in only partial darkness, in order to make sure that no wires belonging to the none too stable collection of apparatus moved when the screen was shifted, the results obtained were not so good as before. They further asked Gutton to let them have the photographic plates developed by some one who did not know what to expect. This Gutton did not grant. It is no wonder that the visitors took away with them no great reliance upon the decisiveness of the experiment.

Early in March Swinton[158] made public his lack of success in repeating Gutton's experiment. He inserted a Duddell thermogalvanometer in the secondary circuit but found no variation of energy to follow the application of the N rays to the primary spark.

Relying upon the promise of Blondlot and Gutton to demonstrate to him objectively the existence of the N rays, Guinchant,[159] like Cotton and Raveau, visited Nancy. In only three or four instances out of several hundreds did he observe a change of the secondary spark in Gutton's experiment with a change in the position of the intercepting screen. As he himself appeared unable to see the difference in the spark, he suggested that Gutton observe while he manipulated the opaque screen. Gutton declined saying that under the suggested conditions the eye of the observer would note no change.

Gutton saw changes in the spark at times when Guinchant saw no change. The latter says the spark varied periodically.

The possibility of a heavy emission from metals has been investigated by Gebhardt.[155] He placed a photographic plate above and one below a sheet of metal, all being in horizontal planes. The lower plate was more affected.

Let us now turn our attention to the various explanations which have been given for the rise and development of this series of rays, in whose existence scarcely any one outside of France at the present time believes. To any person who is inclined to feel a sense of superiority because the delusion was not cherished by any distinguished physicist of the English speaking world, a perusal of the series of papers on Hot Ice in Nature, vols. 22, 23, 24, is recommended as a corrective.

The discovery of the N rays was announced at the psychological moment for obtaining belief in them. The kathode rays, the canal rays, the X rays, the α, the β, the γ rays had accustomed the scientific mind to hospitality towards new rays of astonishing properties. Moreover Prof. Blondlot, the sponsor for the N rays, was not a man of unknown repute, but a physicist fifty-four years of age, whose name was attached to nearly two score of papers in the Comptes Rendus, who was elected correspondent of the Academy of Sciences to fill the vacancy caused by the death of Helmholtz, and to whom was awarded the Gaston Planté prize in 1893 for his studies in the propagation of electricity and again in 1899 the La Caze prize in physics. The estimation in which his ability was held by his fellow scientists of France is indicated by his association with the men named below to form the group of Correspondents in general Physics of the Academy of Sciences at the beginning of 1905,—Crova, Rayleigh, Bichat, Hittorf, van der Waals, Michelson, Gouy, Benoit, H. A. Lorentz.

Pellat and Girardet explicitly say that they accept the N rays because of Blondlot. The Revue Scientifique[206] says: "At the very first, when M. Blondlot announced his resounding discoveries, the universal reputation of this eminent physicist permitted no mind to fail to accept as facts definitely won for science the published results of his remarkable initial experiments." To this result the admirable style of the papers no doubt contributed.

The suggested explanations of the N-ray phenomena fall into four classes:

A. Deceit.
B. Physical Factors.
C. Physiological Factors.
D. Psychological Factors.

A. Deceit.

Of course no imputation of this character attaches to any of the scientific workers in the field of the Blondlot rays. It has, however, been suggested that Prof. Blondlot is himself the victim of the machinations of some one. "A solution is urgent and that for the good renown of the University of Nancy itself."[178]

B. Physical Factors.

1. Heat Radiation.—It may be that temperature changes play some part in the photographic methods of registering the effects of the N rays.[214]

Blondlot[29] as early as May, 1903, noted that the effect of his new rays on the phosphorescent screen is like that of heat and in his next paper[30] he guarded against the radiant heat of the sun falling upon his screen. In the paper[31] which followed this he establishes that the N rays cause no rise in temperature in bodies on which they fall. Later[41] he institutes a comparison between the effects of heat and of N rays on the phosphorescent screen. It was found that, while the N rays increase the quantity of light emitted normally to the surface and lessen the quantity emitted tangentially, heat on the other hand causes an increase in all directions. Further the contour of a key held in front of a phosphorescent screen is made sharper by letting N rays fall on the screen than by raising the temperature of the screen. This is true only when the line of sight is about normal to the screen. The reverse holds when the eye views the key obliquely.

Ballet[3] and Lambert[118] were at pains to avoid the effect of heat. Charpentier[64] maintains that the action of his physiological rays is not to be confounded with that of heat. The interposi-

tion of a sheet of aluminium or of a layer of water does not destroy the effects of the rays. A frog emits the rays even though below the temperature of the laboratory. D'Arsonval[210] tells that to avoid calorific effects experiments were performed in a room warmer than the human body, and that the usual results were obtained. Hooker[113] describes an experiment in which the physiological rays passed through the arm of a corpse and then acted on a screen.

After fruitless attempts to repeat Blondlot's and Charpentier's experiments had been made, recourse was had to heat effects for an explanation. Brown[146] states that he independently discovered zinc sulphide to grow brighter when brought near the human body, but that he later found the cause to be heat. Swinton[187,188,189] after failing in his first experiments afterwards found it easy to get results, but held heat to be the agent. A screen laid on the foot grew brighter, but a still warm boot was as effective. The imperviousness of water to the N rays is due, he supposes, to its adiathermancy.

Schenck,[184] McKendrick and Colquhoun,[173] Rothé[137] and Pieron[178] all agree that heat is important. Dufour[153] found temperature to modify the luminosity of the blue CaS screen as well as that of the yellow ZnS screen. Bringing a finger near the screen makes it brighter. The bulbs of two identical thermometers were coated with CaS. Both were exposed to light and then put in a dark room. When the temperature of one was raised from 12° to 28° it appeared more luminous. This faded as the thermometer cooled, so that at 20° it was only as bright as the other at 12°, and at 16° it was less bright. Hackett[111] found hot water (60°) to increase the brightness of the screen 5%.

The Revue Scientifique[206] makes the charge that the investigators of the new rays had not taken sufficient pains to guard against heat effects. This is certainly true in many instances.

2. Decay of Phosphorescence.—The emission of light from a phosphorescent body lessens as time passes. Schenck[184] suggests this as a factor in the results observed. This could have been subjected to control by comparing two identical screens, only one of which was acted on by the N rays.[206]

3. Change in the Distance of the Screen from the Observer.—Lullin[170,171] directs attention to the change in the appearance of the screen as depending on its distance from the eye.

C. Physiological Factors.

1. Tiring of the Eye.—This was suggested as an element in the problem by the Revue Scientifique.[206]

Pozdena[179] says that when the eye is tired the Ca S screen seems to approach and to recede and to be surrounded by a feebly luminous vapor.

La Roux[169] found that, if you look at the phosphorescent screen with one eye only, it grows darker. A time comes when obscure clouds pass over its surface. Some people see oscillations of brightness. The original appearance can be regained by exposing the eye to white light or by coughing or otherwise making a noise. This explains why Ballet[3] avoided speaking during an experiment. Blondlot[52] however regards the tiring of the eye as an obstacle to successful experimenting.

Hackett[111] remarks that resting that part of the retina receiving the image by closing the eyes or otherwise will cause an apparent increase of brightness.

2. Change of the Position of the Image on the Retina.—Hackett[111] says: "To an inexperienced persons a phosphorescent screen appears to be going through a series of bewildering variations. The greater part of these, if not all, are due to motions of the eye." When the image is transferred to an unwearied part of the retina the object looks brighter. He of course endeavored to train the eye to avoid this source of error.

In December, 1903, Lummer[172] directed attention to von Kries's theory of the function of the retinal rods and cones. In the *fovea centralis,* on which the image of an object falls when we look directly at it, only cones are found, while the rest of the retina has both cones and rods, the latter preponderating in the peripheral areas. The cones have to do with the sensation of color, while the rods are color-blind. They come into play in faint illuminations, furnishing a sensation of colorless light. Moreover their sensitiveness is more augmented in the dark than that of the cones. The owl has only rods in its eyes.

In direct vision only cones are concerned while rods also are affected in oblique vision.

When the temperature of a body is gradually raised there are two sharp changes.

a. From darkness to gray-glow, when the radiation is first sufficient to affect the rods.

b. From gray-glow to red-glow, when the radiation is first able to affect the cones.

If a platinum wire at 400° C. is looked at directly it cannot be seen, because its radiation is not sufficient to affect the cones of the *fovea centralis.* But if the eye is turned so that the image of the wire falls outside the *fovea centralis,* it becomes visible, since less energy is needed to excite the rods than the cones. According to Gotch[157] this effect can be seen in the spinthariscope.

Even when a body can be seen both by direct and by indirect vision its appearance is not the same in the two cases. It will appear brighter by indirect vision. The reader can verify this in the following manner: Fix the eyes on a very faint star, then turn the axis of the eyes slightly aside. The star will now appear brighter. Arago said: "To see the really difficult stars it is not necessary to regard them." Le Roux[120] says he failed to see the phosphorescent screen when he turned his eyes toward it, but did see it when he looked in a different direction. Lullin[170,171] made careful observations leading to the same result. He attributes the change, not to the difference between the rods and cones, but to the varying sensitiveness of the different parts of the retina. Chauveau[151] tells that one morning in a dark room he noticed a piece of paper. When he turned his eyes full upon it he could not see it. As the light grew stronger this phenomenon ceased. An observation made by Pozdena[179] is germane to the matter. When a Ca S screen is moving in a dark room with uniform speed in a straight line the eyes of the observer will follow its motion and he will see it by direct vision. If, however, the speed of the screen on the direction of its motion is changed, the eye does not at once follow the change and thus the image of the screen is no longer on the *fovea centralis* as it was in direct vision but is to one side of that spot. Hence an increase of brightness results, since the rods are more sensitive.

Many experiments made with the N rays present just such conditions as are needed to call forth the changes of appearance described above. Small feebly luminous surfaces are viewed in darkness. Involuntary motions of the eyes are frequent. Suppose that the dim surface of a phosphorescent screen is looked at and that the observer in the belief that a beam of N rays has been

falling upon the screen, now shifts a sheet of lead so as to cut off the beam. He expects an effect and to see it will look at the luminous surface more intently. This will bring the image upon the *fovea centralis* with its less sensitive cones. The image will thus appear less bright, and not only this, but it will appear reddish, since the image is transferred from the color-blind rods to the color sensitive cones. Platinum at 700° C. is red when viewed directly, but by indirect vision it is a peculiar colorless white, and is also brighter. If the observer removes the lead an unconscious shifting of the eyes will correspondingly change the position of the image, and he sees the screen as whiter as well as brighter than before.

In speaking of the change in the appearance of an image seen after reflection from a knitting needle when the N rays fall upon the latter, Blondlot[32] says: "It was then easy to establish that the action of these rays re-enforces the image, for, if they had just been intercepted, this image darkened and became reddish." Also in his examination of the action of a beam of polarized light on a small electric spark, he says (Paris, C.-R. Acad. Sci., 136, p. 487, Feb. 23, '03,): "It is instantly seen to weaken and to become reddish." When a large screen is used the whole of its image cannot fall on the *fovea centralis* and a change of appearance by shifting the eye will not be evident. It is significant that when Blondlot[41] used a relatively large screen, 5x12 cm., he failed to find its appearance changed by the N rays.

Lummer and Rubens [197] found that merely changing from direct to indirect vision made the brightness of the object viewed four times as great, while a change of only one-third in the intensity of a faint illumination is needed to be observed by a well adapted eye.

Throughout the literature of these rays there is frequent reference to the sluggishness with which the effects follow the beginning of the action of the rays.[29,30,31,32,33,34,36]

Blondlot[33] attributes this to storage effects. Broca[61] finds it to be lessened by the use of thin layers of Ca S in making the screen. On the other hand, Lummer[172] suggests that it may be explained by the time required to fix the eye.

Both Salvioni[183] and Nagel[175] are of the opinion that the position of the eye with respect to the object makes a difference in its appearance.

3. Change of Accommodation.—Blondlot[52] holds that accommodation must be avoided in order to see the effects of the N rays. H. Poincaré[210] attributes his own failure to see the effects he sought to involuntary accommodation. Ballet[3] strove to avoid change of accommodation. The Revue Scientifique[211] claims that when the accommodation is relaxed the pupil grows larger, thus allowing more light to enter the eye, with result of a brighter image. Moreover the effort not to accommodate will itself produce changes in the appearance of the phosphorescent screen.

Pointing in the opposite direction is the observation of McKendrick and Colquhoun[173] that the light of the screen became steady after accommodation had been relaxed.

4. Opening the Eyes to Varying Extents.—Ballet[4] warns against opening the eyes wider as this will allow more light to reach the retina.

5. Periodic Changes in the Curvature of the Lens of the Eye. —Heinrich and Chwistek[166] find that such changes cause a dark point on a white surface to appear and disappear at intervals.

D. Psychological Factors.

"The names of the physicists who have been the victims of such surprising illusions will remain imperishable, for works on psychology will repeat them from age to age."—Le Bon.[212]

1. Reaction of the State of Expectancy on the Muscles of the Eye.—McKendrick and Colquhoun[173] ask: "Can it be that the mental condition of some observers in a state of expectancy reacts on the intrinsic muscles of their eyes, and that they see what they think they should see?"

2. The Calling Up of One Sensation by the Presence of Another Which Usually Accompanies the First.—According to Rosenbach,[180] if, in a totally dark room the hand be moved in front of the well rested eye, either open or closed, the field of vision darkens and perhaps even the fingers appear to be visible. With a single finger before the eye its position, whether vertical or horizontal, can be seen. If a sheet of paper be held before the eyes the hand and fingers can no longer be seen. The muscular sensations produced by moving the hand call forth the accompanying visual image.

Testimony to the same effect is borne by Gehrcke.[156] He noted a change in the appearance of a phosphorescent screen when he moved a file behind it. The file at rest had no effect. The finger or a pencil acted as well as the file. Removing the screen did not keep the effect from appearing. The experiment succeeded best when the sound of the object scraping along the screen could be heard. When some other person moved the file nothing was seen.

Much emphasis is laid by Blondlot and others upon the necessity of the observer's manipulating his apparatus himself. It therefore seems very likely that when the observer moved an opaque screen into the path of the N rays his muscular sensations may have evoked optical ones which seemed objective to him.

3. Suggestion and Expectancy.

> "Of all the myriad moods of mind
> That through the soul come thronging,
> Which one was e'er so dear, so kind,
> So beautiful as Longing?"
>
> —*Lowell.*

A perusal of the literature of the N rays leads to the thought that the investigators often had the satisfaction of finding what they expected to find. Blondlot[29] found silver covered with soot to be a better radiator of N rays than when bright, and quartz to rotate the plane of polarization. Bagard[1] discovered the rotation of the plane of polarization of the N rays by tartaric acid to be in the direction indicated by theory. The law of Stokes for fluorescence is followed by the secondary radiation emitted by a body which has stored the N rays, according to Bichat.[22] The fact that a target can in general be reached by a projectile for two different elevations of a gun found its analog in the case of the heavy emission falling on the phosphorescent screen.[43] When Blondlot[34] found that N rays falling on the eye produced an effect upon the appearance of objects, he was astonished because, since water is opaque to the rays, he supposed the humors of the eye would absorb the rays before they reached the retina. Forthwith the difficulty is solved by finding that salt water is transparent to the rays.

Weiss[210] of Paris notes that Charpentier's determination of the wave-lengths of nervous impulses by use of his physiological rays gives about the same result as those obtained by the same

experimenter by another but faulty method. It seems not impossible that the results of the two methods were unwittingly made to agree.

It would, however, be totally unfair to give the impression that suggestion and expectancy as sources of error were overlooked by the workers with N rays, or that they always found what they looked for.

Blondlot[33,34] was astonished to find the appearance of a clock-face to change when N rays fell on the eye, and again to note that the phosphorescent screen continued to be affected by the N rays from a Welsbach light after it was extinguished. Bichat[19] found lead to be transparent to the rays, whereas his colleague, Blondlot, had found it opaque. J. Meyer[212] found many experimental results to run counter to his expectations. The path of the heavy emission proved not to be parabolic, as is approximately the case with projectiles. Surprise is manifested by Charpentier and Meyer[100,101] at certain phenomena they observed in inhibition, and by Macé de Lépinay in connection with his observations on sonorous vibrations.

Ballet,[4] Meyer,[126] Lambert [118] and Le Roux[120] tried to avoid the influence of expectancy upon their results.

In spite of this attitude of caution on the part of some of the investigators it is surprising how much stress is laid upon the necessity of the same persons both observing the effects and also setting in action the causes.

Broca[61] confesses: "I am deceived regularly when I do not operate the tube (containing Ca S) myself."

Upon Guinchant's[159] requesting Gutton to observe the spark while he took charge of intercepting the beam of N rays, the latter declined, saying that the method proposed would give no result as the eye does not perceive the variations of brightness when the mind is preoccupied with searching out the nature of the phenomena perceived.

Hackett's frankness is refreshing.[111] "It is a great obstacle in experiments in N rays that one does not know what change to expect." Wood[52] was warned by Blondlot that a person observing a phosphorescent screen could not necessarily tell when another threw the N rays on the screen. This was explained by the analogy of an observer watching a sensitive galvanometer. The image may be shifting, but, if the observer has the key for

closing the circuit in his own control, he can select a moment when the image is steady, close the key and thus find whether a current flows.

Some N ray workers adduce evidence in which the observer and the manipulator are distinct persons. Bichat[19] by using the N rays could tell the difference between a board painted with white lead and one covered with zinc white. Lambert[209] saw three persons pick out from six similar test tubes the one which emitted N rays. He himself several times detected the approach to the screen of an N ray source by his aid. Miller[133,134] and Macé de Lépinay[121,122] make similar claims. On the other side let it be remembered that when Wood substituted a piece of wood for a file or removed the refracting prism entirely the trained observer saw no change in the N ray phenomena.

Salvioni[183] believes suggestion to be most important. When he tried interposing screens of whose nature, whether opaque or transparent, he was ignorant, he found his results in the refraction of the N rays to lose their regularity. When Turpain[190] knew what to expect his results were like those of other investigators. He found the N ray effect in 81% of his trials. When, however, he had to rely upon his powers of observation, unaided by suggestion or expectation, the percentage fell to about 50.

In the development of the photographic plates used in connection with the spark experiments there is also room for unconscious prejudice in favor of one image. Perhaps Gutton's refusal[178] to have the plates developed by an impartial person points in this direction.

There was certainly no such conscientious and painstaking effort made by any one who believed in the N rays to avoid the effects of suggestion and of bias as was made by Pozdena[179] in his investigation of the heavy emission. He found no trace of evidence for its existence.

Burke's reference[149] to "an enthusiastic atmosphere which his (Blondlot's) experiments, his personality and strong convictions have created all around him," no doubt indicate the explanation of a large part of the N ray phenomena.

4. Hypnotic Sleep.—Sustained gaze at a small bright object is a means of inducing this state.—Burke.[147]

5. Unconscious Imitation of Previous Acts.—Pozdena[179] found that if he had already seen a phosphorescent screen bright

in a certain position he was more likely to see it bright in the same position again than elsewhere.

In Turpain's review[190] of Mascart's experiment he suggests that unconsciously giving the same number of equal impulses to a screw may account for the agreement between readings made by the same observer.

It would not seem difficult to devise a test by which the existence or non-existence of the N rays could be demonstrated. Debierne[205] suggested that a number of similar boxes be taken. In some of them let sources of N rays be placed. Let Blondlot in the presence of other physicists note the boxes from which the rays come. In pursuance of this suggestion the Revue Scientifique[216] in February, 1905, asked both Blondlot and Charpentier to assist in such a test. Both declined, the former saying: "The phenomena are much too delicate for that."

Wood[193] has suggested that Blondlot meet with Lummer and Rubens and that they together thresh out their disagreement as Pender and Cremieu did. This would certainly settle whether there is any effect produced upon the electric spark, which Blondlot maintains but which no one outside of France can find.

It is indeed unfortunate that "This affair of the N rays has raised in the French scientific world real passion."[221] After the death of Bichat his god-son Gutton, who had published papers on the N rays, was a candidate for the vacant professorship in physics in the University of Nancy. Turpain, whose results were adverse to the existence of the N rays, was also suggested for the position. The Revue Scientifique exerted its influence for the latter, but Gutton was named for the position.[223,224]

It is interesting to observe no hint of doubt in the existence of the N rays in the brief sketch of them given by Bouty in the third supplement to Jamin's Cours de Physique, 1906.[261]

In view of what has been said, it would indeed be wise to follow Faure's[154] suggestion that those who are to spend their lives in experimenting should receive instruction not alone in the technique of experimentation but in such allied sciences as will render the recurrence of a second N ray episode unlikely.

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According to the *Electrical Review* investigation has shown that various alloys of manganese, copper and aluminum possess magnetic properties, although they contain no metal of the so-called magnetic group. These alloys have upset the theory of magnetism formerly held. The most promising view now is that magnetism is a molecular property, a property of groups of atoms or groups of molecules rather than of single atoms alone.

According to the statistics presented by F. Z. Shellenberg before the Engineers' Society of Western Pennsylvania, 67 per cent. of the accidents in Pennsylvania coal mines are due to falls of roofs and sides, while only 9 per cent. are due to gas and 4 per cent. to explosives.—*Eng. and Min. Jour.*

The Brazilian Government is about to levy a heavy export tax upon monazite sand, which will affect the incandescent gas mantle industry generally.—*London Engineer.*

INVESTIGATION OF STEEL-HARDENING METALS.

So many investigations have been carried on in connection with the manufacture of crucible steel and of high-speed tool steel that further advance in this direction would seem most improbable, but the combination of other metals with steel has now fully shown that they give it specific properties that adapt it especially to particular uses.

The known steel-hardening metals, named in order of importance of production and use, are nickel, chromium, manganese, tungsten, molybdenum, vanadium, titanium, cobalt, and uranium. The value of these metals produced in the United States in 1906 amounted to $458,327, of which $393,667 was for tungsten. The price of tungsten, which has been increasing for a number of years, was quoted at $5 to $6 per unit (1 per cent. of a ton) in 1905, and at $12 per unit in the spring of 1907. Only small quantities are at present imported into the United States, as European markets utilize practically all that is produced in foreign localities, mostly in Peru and Australia. Large deposits of tungsten are found in Australia, and it is not improbable that sufficient may be obtained there to permit a cetain portion of it to be shipped to the United States, but for the present this country will have to look within its own borders for sources of supply.

The increased demand for the steel-hardening metals has stimulated prospecting for the ores in the United States, and information concerning them is eagerly sought. So many inquiries have reached the United States Geological Survey that a special investigation of the subject has been planned, which has been assigned to Frank L. Hess. In the course of this work, which will extend throughout the summer and into the fall, Mr. Hess will visit South Dakota Idaho, Colorado, Montana, Washington, Oregon, California, Nevada, Utah, and Arizona. The results of Mr. Hess' work will be reported in a bulletin on the steel-hardening metal deposits other than manganese.

INVESTIGATIONS OF LIME-PHOSPHATE DEPOSITS OF THE WEST.

The extensive exploration and development work now being done on the lime-phosphate deposits in Idaho, Oregon, and Utah afford an opportunity for a detailed geologic study of phosphate deposits that will be used to great advantage by the United States Geological Survey. The pits and trenches dug to determine the position and character of the beds must be studied while still freshly made, as they rapidly become filled with débris from the surface, which renders their examination difficult.

F. B. Weeks, of the Survey, who made a preliminary study of some of the workings last fall, will begin field work about the middle of August and continue it until the middle of October or later. The deposits occur over considerable areas in southeastern Idaho, southwestern Wyoming, and northeastern Utah, and prospecting has been carried on at a number of widely separated localities. Beds that are of good grade but too thin to be profitably worked have also been discovered in Nevada, and it is probable that further exploration will show that these phosphates have a wide distribution.

A Convenient Means of Determining the Ash in Graphite

By S. S. Sadtler,

Member of the Institute.

Very recently the writer had occasion to make a number of tests of the mineral residue (and total carbon) of a number of samples of flake graphite of different degrees of fineness. It happened that the analyses had to be finished with considerable rapidity, but the residue had to be left in such a condition that it could be analyzed for iron oxide and silica.

Mr. P. B. Sadtler suggested that it might be done by using the inner crucible, described by the writer in a paper on* "The Determination of Sulphur in Halogens in Organic Substances." The reason for selecting this form of crucible was that it was narrowed from the bottom to the top, so that the cross section of the opening was much less than the bottom of the crucible. The measurements of a small crucible were: Diameter of the opening, 15 millimeters; diameter of the bottom, 25 millimeters; measurement of side, 40 millimeters.

The amount of graphite weighed out for analysis was about one-third of a gram. It was found that with the very fine flakes, that the heat of combustion was so great that the residue fused, and while this did not interfere with the determination of the total amount of the residue, it made it hard to remove it from the crucible and analyze it.

It was therefore found necessary to mix a small amount of carefully ignited magnesia with the finer flaked grades. The amount used, however, was only about twenty milligrams. In the coarser grades a little magnesia was also used, but the amount was only about five milligrams, as more magnesia rendered it more difficult to burn completely.

In carrying out the analysis, the amount mentioned was weighed into the crucible, containing the requisite amount of mag-

*Jour. Am. Chem. Soc., XXVII, Sept., '05, p. 1188.

nesia. These were then intimately mixed and shaken down to a small pile in the bottom of the crucible, when tipped at an angle of about 30°, or as found convenient for burning. It is then placed upon a platinum triangle, over an ordinary blast lamp, so that the combustion might be started and more or less regulated thereafter.

The chief precautions found necessary to completely burn the graphite were to prevent blowing out either the graphite or the ash with the current of oxygen, and to keep the mass together and continually burning, as light flakes driven to other parts of the crucible would take some time to become consumed.

It was, therefore, found desirable to get a suitable stream of oxygen, which was delivered to the crucible by means of a clay pipe stem, and hold it first at the opening, to gradually bring it in, and run it over the surface, so as to slightly sinter it. Then, beginning at one edge, to gradually bring the combustion through the mass, keeping the temperature at very bright incandescence, the observer using cobalt glass for protection to his eyes. When no more bright indication of combustion is perceptible, all graphite should be consumed, but it is well to keep a small stream of oxygen playing into the crucible for five or ten minutes, to be sure of the reaction being completed.

When the analyses were first started, duplicate determinations were made on about six grades, which showed but slight variation, namely up to about .3%, based upon the sample taken. The writer did not expect to publish results at the time, and cannot give figures except those selected as the results taken.

These are given as follows, and show a rather uniform gradation of the total carbon in the separations of a practical manufacturer.

The first series are comparisons of the same grading, but some difference in the manner of separation:

SERIES NO. 1.

	No. 1 Crucible.	No. 2 Crucible.	1-19 Dust.	2-19 Dust.
Ash	5.07	7.46	33.70	60.25
Carbon	94.93	92.54	66.30	39.75

SERIES NO. 2.

	No. 1 Crucible.	No. 2 Crucible.	1-19 Dust.	2-19 Dust.
Ash	5.76	6.52	12.93	42.30
Carbon	94.24	93.48	87.07	57.70

SERIES NO. 3.

	No. 1 Lub.	No. 1 Lub.	50 Flake.	75 Flake.	100 Flake.	130 Flake	150 Flake.
Ash..........	2.65	6.16	7.93	10.60	15.50	18.20	33.10
Carbon.......	97.35	93.84	92.17	89.40	84.50	81.80	66.90

With regard to the oxygen used, it is probable that any good commercial grade would be satisfactory. The writer, however, happened to have an "oxone" generator, and used oxygen made therein, which, of course, is nearly 100% pure gas, and differs from that made in some ways, notably from liquid air, which has been upon the market. If made from chlorate of potash and manganese dioxide, the percentage of oxygen should be nearly as high. It may, however, be that it would not be requisite to have pure oxygen, although the larger the percentage of oxygen, the less the force of the stream impinging upon the graphite would have to be for the same activity in combustion.

Laboratory of Samuel P. Sadtler & Son,
July 15, 1907.

GRAY IRON ORES OF TALLADEGA COUNTY, ALA.

The gray iron ores of Alabama occur in a belt that is confined almost entirely to Talladega County, and although this belt of ore has long been known, having been reported by Tuomey in 1858, but little attention has been paid to it as a source of iron. The only company now in active operation in this region is taking out ore at but one locality—the Mesaba or Tallaseehatchee mine, on Tallaseehatchee Creek.

Practically all the so-called gray ore is hematite, but in places the percentage of magnetite is so large that the ore is somewhat magnetic. Its name, derived from the ashy gray color which it takes on weathering, not only describes it but serves to distinguish it from the brown or red ores of the northern part of the State.

The economic importance of these gray ores is regulated by four factors, all of which should be carefully considered before extensive development work is undertaken. These are cost of mining, value of ore, cost of smelting, and opportunities for marketing products. These factors, as well as the occurrence and character of the ore, are briefly discussed by Philip S. Smith in a paper recently published by the United States Geological Survey as part of its annual volume on economic geology (Bulletin No. 315), copies of which may be obtained by applying to the Director of the Survey at Washington, D. C.

PRODUCTION OF BAUXITE AND ALUMINUM IN 1906.

The production of bauxite in the United States in 1906 amounted to 73,332 long tons, valued at $368,311. Compared with the production in 1905, 48,129 long tons, valued at $240,292, the production in 1906 has increased 27,203 tons—nearly 57 per cent.—while the average price per ton remains almost the same. Arkansas still leads in production, the other producing States being Georgia and Alabama.

The use of low-grade bauxite for the manufacture of refractory brick and the prospective new developments in the aluminum industry have stimulated interest in deposits of bauxite. In Tennessee developments have already begun on deposits at Missionary Ridge and at East Lake and Sherman Heights, suburbs of Chattanooga. Bauxite has been noted in California and also in Kentucky.

Bauxite in the form of bricks has proved to be of great value as a refractory material for lining basic open-hearth steel furnaces and lead-refining furnaces, being superior to fire brick for these uses.

As an ore of aluminum bauxite is still in great demand. The production of aluminum has increased in twenty years from 18,000 pounds to nearly 15,000,000 pounds annually, its production in 1906 having been 14,910,000 pounds. This increase in production was accompanied by a very substantial reduction in price. The application of the metal to new uses from time to time and its increased employment in old ways has caused a constant demand for it, which has not been fully supplied.

Recent plans of the Aluminum Company of America, formerly the Pittsburg Reduction Company, contemplate the erection of a model factory town, comprising 200 new houses, for the employees of its factories at Massena, N. Y., and a mill for rolling aluminum sheets at its New Kensington, Pa., plant.

Projects are under way which, if realized, will place in the field several competitors for the aluminum trade. One of these projects, it is reported, will be located on Cumberland River, about twenty-five miles from Williamsburg, Ky., where the river falls about sixty feet. The enterprise involves the construction of a dam which will provide 20,000 horsepower at any season of the year.

An advance chapter from "Mineral Resources of the United States, Calendar Year 1906," on the production of bauxite and aluminum in 1906, by E. F. Burchard, is now ready for distribution. The pamphlet comprises a note on aluminum salts, including alum and aluminum sulphate, with descriptions of undeveloped deposits of these salts in Nevada and New Mexico.

Much difficulty is usually found in making paint adhere firmly to galvanized iron. The United States Government has adopted specifications which appear to give satisfactory results and which call for the use of vinegar in washing the surface before painting, which washing roughens or corrodes the surface and gives the paint better adhesion.—*Eng. and Min. Jour.*

Mechanical and Engineering Section.

(Stated meeting held Thursday, April 11th, 1907,)

Direct and Indirect Methods of Electrical Purification of Water.

By Henry Leffmann.

It is about a century since the results of electrolysis began to attract attention, but the commercial exploitation of the processes was impossible until the economic production of the processes practical. So far as the purification of water is concerned, but little result was expected from electrolytic methods until the discovery of the microbic life in water and its relation to disease. The latter discovery was promptly made the basis of a rapid and brilliant, but in some respects untrustworthy development. Water analysts, and sanitarians generally, were often misled by the statements emanating from bacteriologic laboratories. Even to-day, we must receive with caution publications from such sources, especially tabulated results of experiments.

It is not necessary to review the history of the application of electrical currents to water purification, nor to describe even briefly the numerous patents that have been granted for such purposes. I propose to refer here only to some that have come under my own observation, in consequence of having been asked to make expert investigations. Some attempts have been made to remove the mineral impurities from water by taking advantage of the electrolytic powers, but most processes have been intended to kill the microbes. The ordinary inventor has proceeded upon his (generally superficial) knowledge that the disease-carrying power of water is dependent upon bacteria, and that electricity in sufficient strength is fatal to living matter.

In some of the processes the method has been the crude one of simply passing electric discharges through the water, hoping to kill the bacteria by direct shock. Thus, in one patent which was submitted to my consideration a few years ago, the inventor pro-

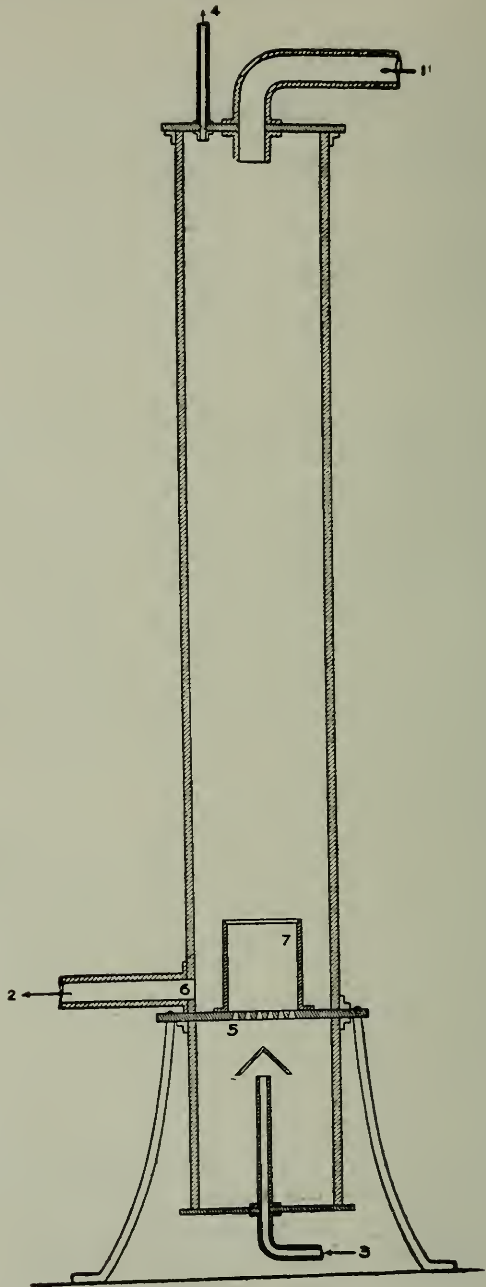


Fig. 1. Scheme of arrangement of tower for mixing ozonized air with the water.

poses to have electrodes passed into the water-main through insulated sockets and discharge a succession of sparks across the stream. The impracticability of the method, on anything but the most minute scale, seems not to have appeared to him, but what I consider much worse, the absurdity was unregarded by the patent office. It has seemed to me that there are limits beyond which the authorities of the patent office should not allow the sanction of their protection. I am well aware of the fact that many processes ridiculed by experts, have been successfully applied, but a limit of permissibility can be set without working injustice. Too many patents are granted that are inoperative and are, or should be, known to be so by the examiners who have experience in such matters.

I have seen in operation several methods of water purification by means of electrolysis. In these aluminum electrodes have been used, and more or less loss of the metal has occurred, it being converted into aluminum hydroxide. This produces its usual effect, that of combining with the organic matter and entangling the suspended substances so that the water, after treatment, can be subjected to a rapid filtration and will show material improvement in microbic content, especially if the amount of suspended matter and microbic content were previously high. On waters containing but little suspended impurity, living or dead, the purifying action is relatively low. The constant loss of the electrode is, of course, a most serious item of expense, generally overlooked in the experimental plants.

Two of the plants in which aluminum electrodes were used may be described with advantage in some detail, as some incidental features are of interest. In one, large aluminum plates two feet long and several inches wide were immersed in the water in a tall jar and the current passed through. The experimenters selected (probably with a view of more profoundly impressing inexperienced observers) very muddy water from the street gutter in front of the building in which the plant was located. The current seemed to cause the mud to collect and settle rapidly and the water became soon fairly clear, but analysis showed ammonium compounds and nitrates in abundance, and it was evident that the purification was nominal. The parties had but little money and were trying to interest a Philadelphia business man, but I could not make any but an unfavorable report.

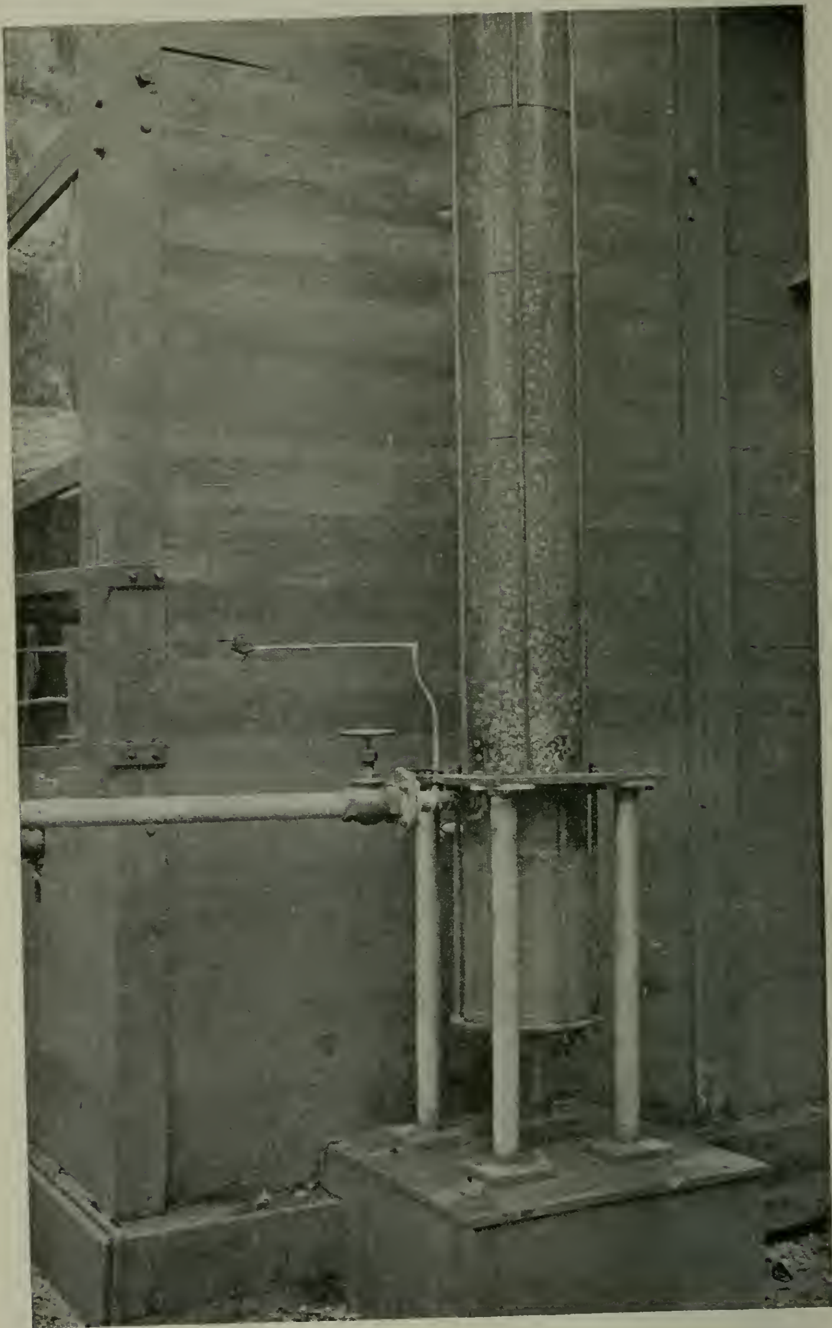


Fig. 2. View of exhibition mixing tower at Philadelphia plant.

In another case I was asked to examine a plant that was in operation near Eighth and Chestnut Streets, Philadelphia. One of the parties operating the plant claimed that the scale-forming ingredients could be removed from Schuylkill water as well as the other impurities. As this was a very broad and seemingly unwarranted claim, I was much interested in the basis for it. The promotor furnished me with a sample of water, said to be Schuylkill (city) water so treated and purified, but on taking the total solids I found the dissolved fixed matter to be just about that of the amount in the city water. It was evident that no material diminution of the dissolved solids had occurred. At the urgent request of the promoters, I visited the plant and found a very elaborate installation, mostly of closed vessels, some of which were taking the street current through ammeters and voltmeters, and from others of which a clear water could be drawn in considerable amount. The operators showed me specimens of water containing a large amount of sediment, mostly in flakes, which they claimed to be the "scale-forming ingredients." I was at first much puzzled by this sediment, as I had not been informed as to the construction of the electrifying apparatus, but when I learned that aluminum electrodes were used I recognized at once that the precipitate was aluminum hydroxide. The process was, of course, entirely unsuited to the purposes for which it was devised.

In the operation of the Anderson process of purifying water by agitation with metallic iron, attempts have been made to get more powerful action, that is, more rapid solution of the iron, by making it the positive pole of an electric system, but no practical advantage seems to have been attained. Recently, a process has been patented in which an electric current is passed from an inner to an outer pipe, the water flowing through the annulus, but I have no practical knowledge of this method.

It seems to me that the most practical benefit of the application of electricity to water purification will come from the indirect methods in which the electrical energy used to produce an active disinfecting agent, and this is then applied to the water. Of all the processes of this type, those which produce ozone seem to be most useful. The material from which ozone is obtained—air—is in unlimited supply and the addition to water cannot be re-

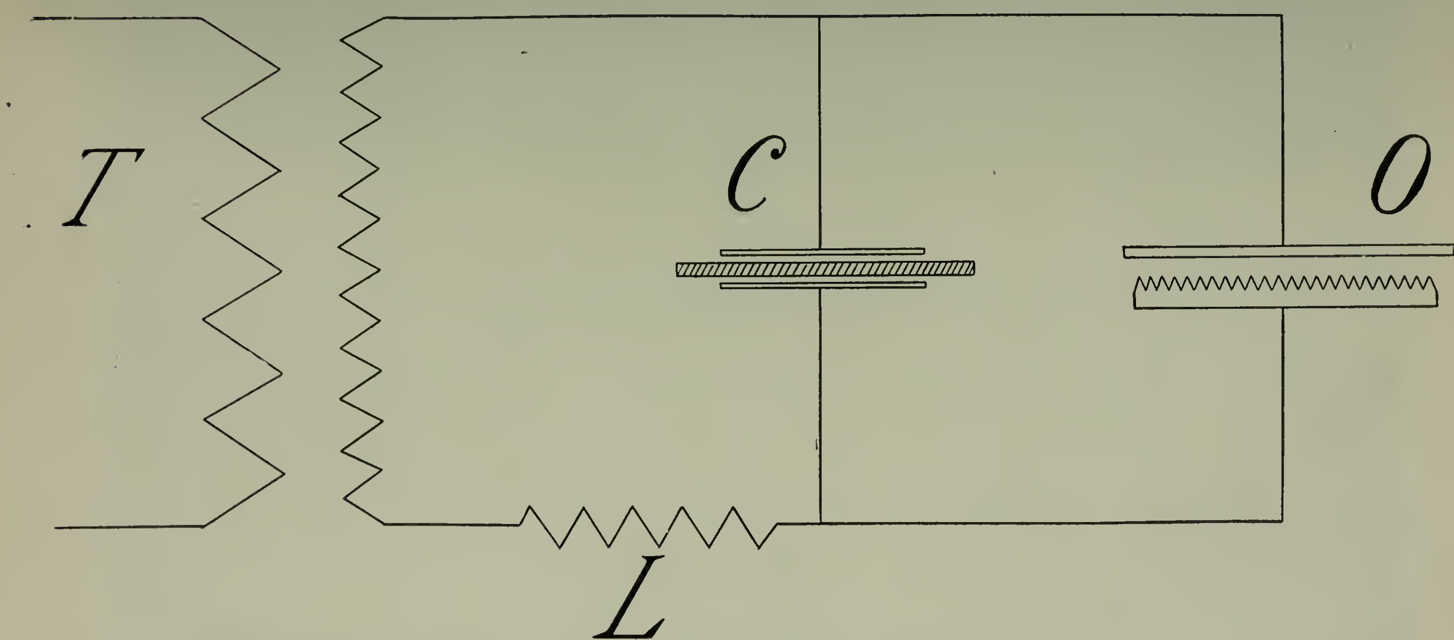


Fig. 3. Diagram of Vosmaer system. T, step-up transformer; C, high-tension condenser; L, high-tension choking coil; O, ozonizing apparatus.

garded as being dangerous, since if present in excess it soon reverts to the condition of ordinary oxygen.

The principal problem in this method is the economic production of ozone. This modification of oxygen can be obtained by several methods of different types, but those in which electricity is employed seem to be alone applicable to the processes in question here. For the purpose, high-tension currents are most economical, and the best yield is obtained by the so-called "silent discharge." It is now known that a spark or arc discharge will produce nitrogen oxides which are corrosive. It has also been determined that the air intended for production of ozone should be dry, otherwise hydrogen dioxide will be formed. The principal mechanical difficulty encountered in producing ozone on the large scale by means of the electric discharge is to secure a suitable dialectric. Glass, porcelain, rubber and other materials have been tried but are so liable to fracture or perforation that serious interruptions of operation frequently occur. Continuity of action is very important in commercial processes, such as the purification of water, and when a large unit of the plant is out of use in order to install a new dialectric, the condition is annoying.

The inventions of Vosmaer seem to overcome the difficulty, for he avoids the use of a special dialectric, employing only the dry air which is to be ozonized. The discharge takes place from thin metal strips on which are saw-like teeth. These strips are held by insulating (porcelain) sockets, firmly in the center of metal pipes. Many of these pipes are combined in parallel, the strips being all connected with one pole and the pipes with the other. An alternating current of high potential is allowed to flow through the arrangement, almost all the current passing by silent discharge, although at times a spark passes, but as there is no permanent dialectric, no damage is done. The sparking is too seldom to produce damage or any appreciable amount of objectionable gases. The drying of the air may be done by any of the known methods; preference is given by Vosmaer to refrigeration, by means of an ordinary ice machine.

A plant capable of purifying many thousand gallons in twenty-four hours has been for some time in operation on the west bank of the Schuylkill River at the foot of Locust Street, Philadelphia. The cuts will show the general arrangements, but a brief description will aid in understanding the operation.

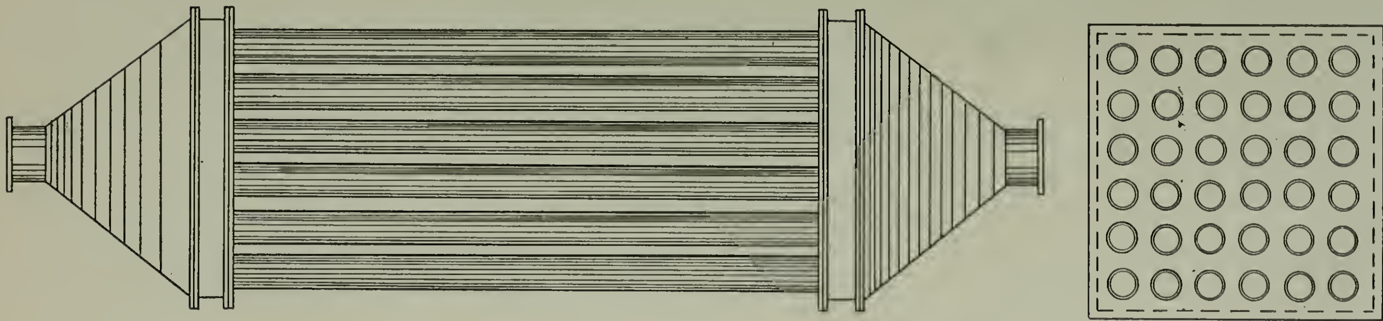


Fig. 4. Longitudinal and end-view of tubes of ozonizer.

The water is first roughly filtered. This operation is merely intended to remove the grosser suspended matter, as the ozone process proper does not accomplish this. As the main part of the operation is the destructive action of the ozone on the bacteria, it is not necessary for the preliminary filtration to be nearly so close as when the latter is the sole reliance (as in ordinary filter plants), hence the filter area in the ozone plant is relatively very much smaller, the rate of filtration being so much greater. The filtered, or, perhaps, we may call it strained water, is passed into aêrating towers. These are tall, narrow vessels, into which the water enters at the top and the ozonized air at the bottom, the latter under considerable pressure. In the experimenal plant above mentioned, an exhibition mixing tower has been installed. This is a glass tube about sixteen feet high and ten inches in diameter. In this the admixture of the ozone current with the water current is well seen. Upon the thoroughness of this mixing depends, in large part, the thoroughness of the purification. The water escapes at the foot of the mixing tower, clear and practically sterile. It sometimes contains a small amount of ozone in solution, but this is not objectionable and soon disappears, either by conversion into ordinary oxygen or by combination.

The advantages of the process may be summarized as follows:

No objectionable chemical is introduced into the water.

Large filter beds are not required.

The operation expenses are not high.

The plant occupies a limited area and the operation is simple and easily comprehended.

The plant may be enlarged by the addition of new units without disturbing the original units.

The sterilization is rapid and certain.

The plant may be placed at any convenient point.

The process seems to me to find even more valuable application to the purification of sewage than to ordinary water supply. Both of these problems are now among the most urgent questions of sanitation. The extensive use of water in our domestic life, with the increasing sources of pollution, give importance to every method of purification, and processes that seem to be founded on scientific principles and seem capable of practical operation on a large scale, and to involve low operative cost, limited land area

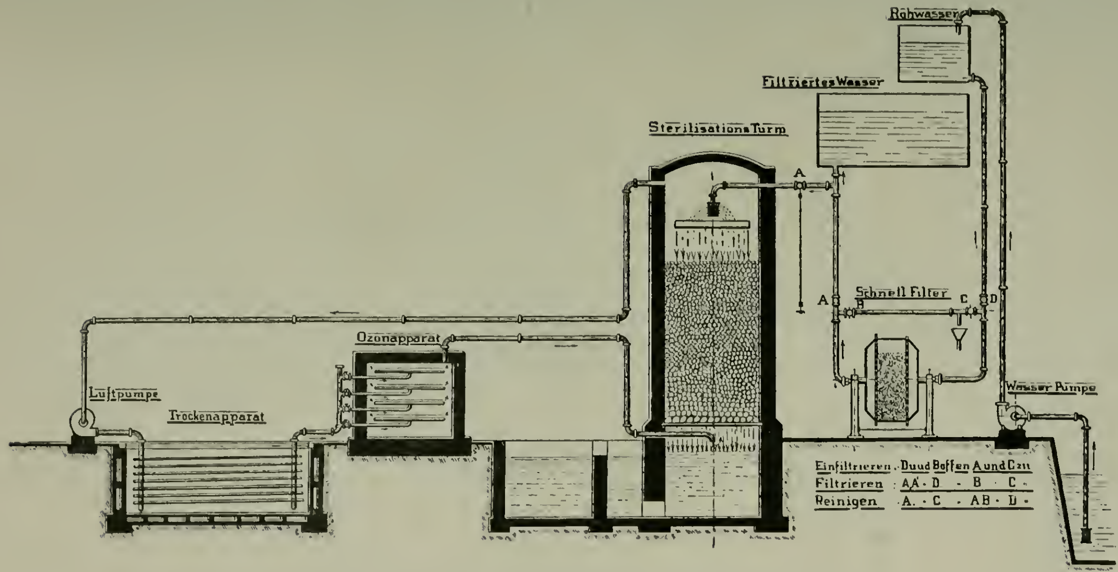


Fig. 5 General view of plant for purification of water by ozone

and freedom from dangerous chemicals deserve careful investigation.

Many tests of the bacteriocidal efficiency of the plant have been made. Some made by myself showed that the water as discharged from the ozonizer is practically sterile. The following more elaborate tests, extending over many weeks, were made by Dr. Rivàs, official bacteriologist of the City of Philadelphia, supplanted by independent tests by Drs. Jackson and Hale, city bacteriologists of Greater New York.

DR. RIVAS.

Date	Sample	Bacteria Before Ozonization (includ'g disease germs)	Bacteria After Ozonization (no disease germs)	Organic Matter in Solution Before	Organic Matter in Solution After
May 15, 1905	1	720,000	16	15.21	7.7
May 15, 1905	2	253,000	37	13.33	8.89
May 18, 1905	1	500,000	55	11.96	7.51
May 18, 1905	2	500,000	38	19.92	7.11
May 19, 1905	1	700,000	5	10.07	6.52
May 19, 1905	2	700,000	0	12.64	6.72
Average		562,100	25		

DRS. JACKSON AND HALE.

Date	Sample	Before	After	B. Coli after Ozone.
May 19, 1905	1	665,000	15	0
May 19, 1905	2	648,000	13	0

More recent tests confirm the foregoing.

The following figures show a series of tests with statement of operative cost:

Date	Quality of Water gals. per hr.	Bacteria Before Ozoniza'n.	Bacteria After Ozoniza'n.	Electrical Expendi'e K.W.hr.	rate per million gals. in K.W.hrs.
Dec. 14, 1905	31,200	1,500	2	6.1	196
Dec. 14, 1905	30,000	2,000	2	6.0	200
Dec. 14, 1905	30,300	2,600	4	6.0	198
Dec. 15, 1905	30,900	2,100	2	5.5	178
Dec. 15, 1905	31,300	1,000	2	5.9	188
Dec. 15, 1905	30,000	1,300	5	5.8	193
Dec. 18, 1905	29,900	5,600	4	5.6	172
Dec. 18, 1905	31,000	1,000	5	5.6	181
Dec. 18, 1905	28,500	1,200	1	5.5	193
Dec. 19, 1905	30,000	750	2	5.5	183
Dec. 19, 1905	29,000	550	4	5.6	193
Dec. 19, 1905	27,000	9,900	19	5.6	208

Dec. 19, 1905	28,000	6,000	3	5.5	197
Dec. 19, 1905	30,000	3,700	4	5.5	183
Dec. 20, 1905	29,000	2,900	1	5.5	190
Dec. 20, 1905	28,400	4,100	2	5.6	197
Dec. 20, 1905	28,400	7,100	5	5.6	197
Dec. 20, 1905	28,000	5,700	5	5.8	207
Dec. 21, 1905	29,000	8,600	13	5.5	190
Dec. 21, 1905	28,000	8,700	11	5.5	197
Dec. 21, 1905	27,000	16,400	15	5.8	215
Dec. 21, 1905	26,000	2,700	6	5.5	212

FOREST SERVICE TIMBER TESTS.

Extensive tests to determine the strength of the commercial timbers of the United States are being made by the Forest Service. Such information is of great value to architects and engineers in that it enables them to use more economically the products of the forest. The tests are made on large beams. The material is generally tested while green, since timber is weakest in the green condition. The strength of a beam is indicated by the greatest fibre stress developed during the test. Technically speaking, this breaking strength is termed the modulus of rupture. By using it the load that any beam will carry can be calculated. In the table below the first column gives the green breaking strength of our principal commercial timbers. The second column gives the greatest load that a timber five inches wide and twelve inches high, with fifteen feet between the supports, would hold if the load were concentrated midway between the supports.

Species.	Breaking strength in bending. lbs. per sq. in.	Breaking load concentrated midway between supports, for a beam 5 x 12 in. x 15 ft. lbs.
Longleaf pine	7,772	20,700
Douglas fir	7,500	20,000
Western hemlock	5,783	15,400
Loblolly pine	5,580	14,900
Tamarack	4,562	12,300
Norway pine	3,975	10,600

If instead of being concentrated at one point the load were uniformly distributed over the entire length of the beam the beam would hold twice as much. In order to insure safety, in practice beams are seldom allowed to carry more than one-sixth their breaking loads.

Mining and Metallurgical Section.

(Stated Meeting held Thursday, January 26th, 1906.)

The Schuyler Mine.

By J. H. Granbery,

Associate Member Am. So. C. E., Member of the Institute.

(*Concluded from p. 28*)

The geological formation is shown in Fig. 1. The illustration shows the face exposed by quarrying for sandstone. All the mining that was carried on for the early part of the operation was done by shaft working; and it is only through the quarrying operations referred to that so much of the bedding plane of the ore body is exposed to view. In the figure is shown a blacksmith shop, and a temporary power plant, used for furnishing the current to operate electric drills. The quarry floor "C" is the top of a bed of red sandstone and shale; the gray sandstone lies in two layers above it. The lower extends from "C" to the lower edge of the seam "B," and the upper extends from the upper edge of "B" to the shale and brecciated trap at "A." The two layers are each, at this exposure, about eleven feet thick; the seam "B" is a shaly slate that runs from six to nine inches thick, and carries about six per cent. copper.

At the opening "D," where it cuts through the two layers of sandstone and the seam "B," the presence of calcite is shown by the white streak where the roof of shale and trap is broken out. The shale and trap themselves, at this point, carry considerable copper. The openings referred to are indicated by the letters "D" and "A" on the accompanying map, Fig. 2. Here the tortuous character of the workings is clearly shown.

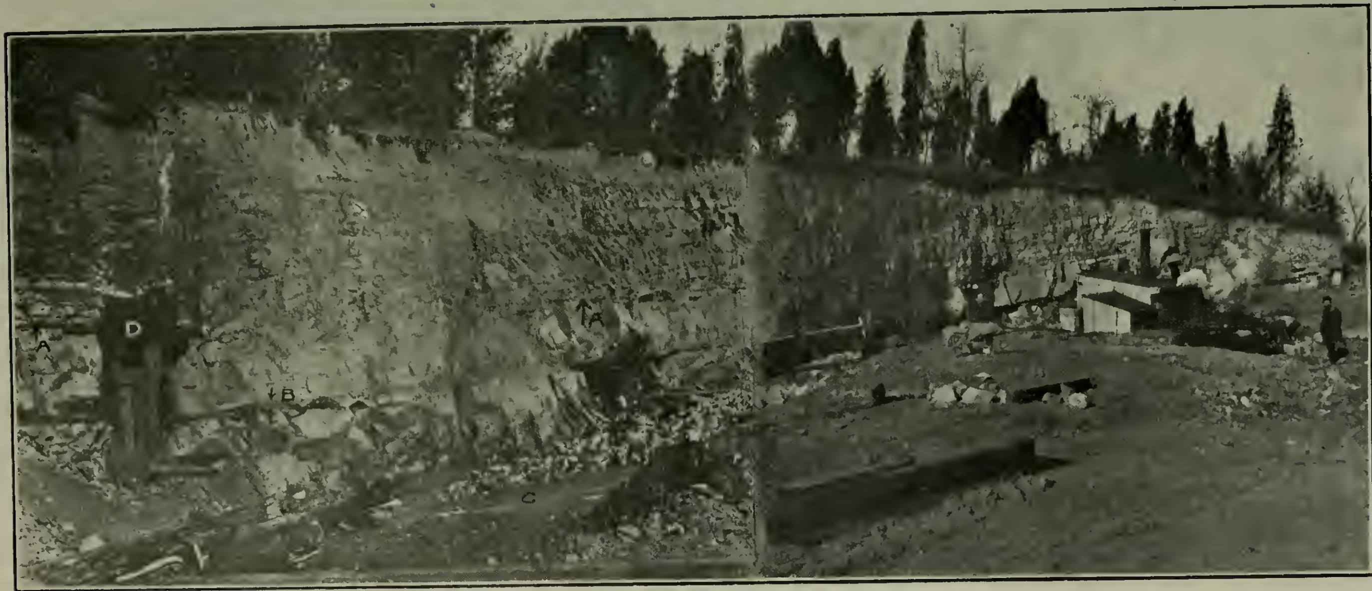


Fig. 1. Geological formation, exposed in the open quarry. The view is taken from the southern end.

Fig. 4. The Victoria shaft.

Drift "D"

Drift "A"

Fig. 5. The quarry—view taken from the northern end.

The process of "following the ore" was apparently profitable, if we may judge by the size and number of stopings that have been carried on.

The map, Fig. 3, shows the outline of the outcrop and gives an approximate scale elevation of the ore body as it is exposed. The dotted lines show the north, south and middle drain tunnels respectively, and the location of shafts is shown by the circles. The middle tunnel, which is the main outlet for drainage, is shown to better advantage in Fig. 2.

With the exception of the "Victoria" and Shaft No. 1, all of the old shafts were caved or had become partially filled up pre-

Fig. 6. The reduction plant, built in 1900-01.

vious to 1899. The other open shafts were reopened by the operators who took over the property at that time; they drove no new shafts.

In Fig. 4 is shown an old ladder, found below the water line, in the Victoria shaft; this was made of oak and had been submerged for thirty-five years; it was very heavy, due to the water it had absorbed, but strong and still capable of hard usage. At the foot of the ladder is shown a section of piping of a form that is unusual at this day; this is the pump valve of the old Cornish pump. The flanges shown were used for attaching the valves. The old pipe was joined, not by flanges or screwed connections as in present practice, but by a method

somewhat similar to the bell and spigot connections used for water mains. The joints were not leaded, but were packed with rope and tar, and then a sleeve was driven on to hold the pipes and the packing in place. Fragments of the old Cornish pump rod may be seen at the extreme left of the figure, and in the open space marked by the cross are still to be seen the foundations of the first steam engine in America.

The stamp mill used by the Brisk company was just off the limits of the picture; and in 1900, when this shaft was retimbered under the author's direction, an old stone wall was unearthed that had, to all appearances, formed the outer wall of the old engine house.

Fig. 5 shows the general appearance of the quarry face and floor after some months of operation. The entrances into drifts are shown, and marked to identify them; the quarry floor is buried under about ten feet of ore—taken out in the interval between making photographs of Fig. 1 and Fig. 5. The South quarry is seen in the distance, and to the left of the illustration is the steel framework for the crushing and milling plant. The plant itself is shown in a more general way in Fig. 6, where the frame for this building is shown partly erected.

At the left of Fig. 6, directly below the small "timekeeper's house," is seen the lock-cribbed shaft for cleaning out the main drain tunnel. This is marked upon the map, Fig. 2, in the lower corner. The stone building in the foreground is the power house, that to the right, back of the well drilling machinery, is the deposition building, where the metallic product was designed to be produced. Between this and the furnace building directly above it were the leaching tanks, four in number, designed to handle 125 tons of ore per day. The brick stack has a column 100 feet high, and the top of its foundation is sixty-five feet above the meadow.

In drilling the well indicated by the location of the machinery for that purpose, ore was found at considerable depth, and the suggestion has been advanced that there may be a secondary enrichment of the country rock at greater depth. No other borings were made to confirm this hypothesis, however, and it is doubtful, even if such confirmation were forthcoming, whether the material could be obtained at a profit under the

Fig. 7. The dump, where quarry waste was disposed of.

circumstances. The well is 343 feet deep, with an eight-inch casing at the top.

Fig. 7 shows an old waste dump, containing something like 5000 cubic yards of mixed gob, ore and dirt. Some of the most perfect examples of malachite were found in the process of excavating parts of this dump. The garden shown in the immediate foreground is the site of the deposition building shown in Fig. 6. This photograph was made during the period of construction in 1900-1901, as were those reproduced in other portions of this article.

ELECTROLYTIC CORROSION OF IRON AND STEEL IN CONCRETE.

In a paper read at the two hundred and fourteenth meeting of the American Institute of Electrical Engineers at New York, March 1, 1907, A. A. Knudson presented the results of research he had carried on for several years to ascertain whether concrete will afford iron and steel the same protection from stray currents of electricity as it gives against ordinary corrosion or rust. In addition to the laboratory experiments detailed the author of the paper refers to two practical cases of the recognition of electrolytic action in important steel structures. The first of these is the bridge over the Gowanus Canal, South Brooklyn, N. Y., at Hamilton avenue. The Bridge Commissioner, in his report for the year ending June 30, 1906, said that the foundation walls developed some rather serious cracks on both sides of the canal, with a movement of the walls toward the center of the canal.

ELECTROLYTIC ACTION ON BRIDGE STEEL.

To ascertain the electrical conditions, Mr. Knudson made some tests at the above mentioned bridge, the results of which are thus stated:

The voltmeter readings show the steel structure to be positive to the canal, positive to water mains in the street, and positive to the trolley rails on the bridge, ranging from 0.5 to 1.5 volts. These readings were taken when the car traffic was light. Some of the cracks on the concrete had been plastered over, but others were quite visible. The tests indicate that the trolley tracks on the bridge are in connection with the steel structure. Tests were also made on another bridge of the same construction a little further north over the same canal, at Ninth street. The readings here were exactly the reverse to those found at the Hamilon avenue bridge, the structure being negative to canal, water mains and tracks. There were no visible cracks in the concrete of either foundation. Although the cracks in the concrete of the Hamilton avenue bridge are attributed to other causes in the commissioner's report, we believe these tests and observations point strongly to electrolytic action from trolley currents as being the

true cause. This seems to us the more reasonable cause of these cracks, in view of the results of our laboratory experiments. Ordinary care would suggest that costly structures of this kind should be periodically inspected for evidence of electrolytic action upon the interior steel work especially if located contiguous to water, or in the vicinity of electric railroads or railroad power stations, as in the case just cited. Furthermore, this question should be carefully considered when such structures are planned, tests made at locations of proposed bridges or other structures, to ascertain the electrical conditions and the possibilities of injury due to electrolysis from stray currents.

PROTECTION AGAINST CORROSION IN BUILDINGS.

The paper cites the "Times" Building, New York, as a conspicuous instance of care to prevent destructive action of electrical currents. One precaution taken there was the thorough waterproofing and draining of retaining walls, this being carried under the floor of the press room occupying the subbasement. As a further safeguard all the steel members up to the street level were encased in Portland cement mortar to the minimum thickness of ¾ inch. This is effectual protection against rust deterioration, and is believed to be also against electrolytic disintegration. As perfect insulation as possible is also provided, there being sufficient grounding to relieve any electrical tension which may exist in any part of the steel frame by drawing off the current at points where electrolytic action cannot be set up.

Accompanying the paper are views of two water meters, the under sides of which were practically destroyed by electrolysis while in service in the cellars of dwellings in a city distant from New York. These cases, which are by no means isolated, illustrate how trolley line currents will follow a service pipe for a considerable distance from the tracks, enter a building, and find an outlet to ground on the damp soil of a cellar. This furnishes an opportunity for current to pass into the iron foundations of large buildings where such service pipes, either water or gas are connected, as they usually are, to the framework of such structures. Mr. Knudson has discovered many similar cases of current straying into buildings in different cities in this country. Three meters were found destroyed in this way in different sections of the city from which they were taken. They were from one to two miles apart. The distance from the tracks of one was 300 feet, and of another 675 feet. All the meters were on side streets at right angles to the car tracks.

CONCLUSIONS AND REMEDIES.

The conclusions reached by the paper and the remedies suggested are thus stated:

Coatings of various kinds of paint or varnishes will be of little use as an insulation, for it must be borne in mind that not only a moisture resistant is required, but an insulation that will resist continual moisture, and also that will stand the pressure of great weight. From laboratory experiments as well as observations in practice, we draw the following conclusions:

1. Steel structures are well preserved from ordinary corrosion by concrete if placed either in salt or fresh water This, however, has long been known.

2. If but a small fraction of an ampere of electricity passes from an interior metallic column or structure into concrete or masonry as usually made, there will be corrosion of the metal and disintegration to the concrete masonry.

3. Structures of steel in concrete that are subject to sea water are in more danger from electrolytic action than those in fresh water, by reason of the lower resistance of concrete in the sea water as shown by the laboratory experiments.

4. In no sense can concrete be considered an insulator, and it is from all appearances just as good an electrolyte as any of the soils found in the earth.

"It is to be expected," says Mr., Knudson, "that so long as the single trolley with its grounded return is in general use, just so long may we look for electrolytic action in some form upon various underground structures; and reinforced concrete is no exception to the rule. It is not at all surprising that such currents are busy at steel work of bridge anchorages. Whether inclosed in concrete or masonry, these materials are no protection from the straying railroad current when the conditions are favorable for electrolytic action. In view, therefore, of the items here presented and of the enormous use to which concrete and hydraulic cements are now put, it would seem that this question should receive due consideration by those who have to do with planning and constructing important public works and buildings, as well as those who are entrusted with the care and safety of such structures."—*Iron Age.*

THE AMENDED FREE ALCOHOL LAW.

In the last week of the recent session of Congress a bill was passed amending the free alcohol law which went into force January 1, with a view to decreasing the cost of producing, denaturing and transporting spirits intended for industrial purposes. It is the opinion of those most familiar with the subject that the passage of this amendatory measure will within a short time reduce the cost of denatured alcohol to the consumer by at least five or six cents per gallon. This prospect, considered in connection with the latest quotation on denatured alcohol of 29 cents per gallon, f.o.b. Peoria, indicates that the prediction made just before the enactment of the original law that the price would be down to 25 cents per gallon within a year will be more than verified. The amendatory law does not take effect until September 1, but in the meantime regulations for its enforcement will have been promulgated and thoroughly digested by producers and dealers, so that it is fair to assume that the effect of the changes will be felt in all parts of the country before the end of the current year. The new statute provides as follows:

TEXT OF THE NEW LAW.

Be it enacted, &c., That notwithstanding anything contained in the act

entitled "An act for the withdrawal from bond, tax free, of domestic alcohol when rendered unfit for beverage or liquid medicinal uses by mixture with suitable denaturing materials," approved June 7, 1906, domestic alcohol when suitably denatured may be withdrawn from bond without the payment of internal revenue tax and used in the manufacture of ether and chloroform and other definite chemical substances that do not appear in the finished product as alcohol; provided, that rum of not less that 150 degrees proof may be withdrawn for denaturation only, in accordance with the provisions of said act of June 7, 1906, and in accordance with the provisions of this act.

Sec. 2. That the Commissioner of Internal Revenue, with the approval of the Secretary of the Treasury, may authorize the establishment of central denaturing bonded warehouses, other than those at distilleries, to which alcohol of the required proof may be transferred from distilleries or distillery bonded warehouses without the payment of internal revenue tax, and in which such alcohol may be stored and denatured. The establishment, operation and custody of such warehouses shall be under such regulation and upon the execution of such bonds as the Comimssioner of Internal Revenue, with the approval of the Secretary of the Treasury, may prescribe.

Sec. 3: That alcohol of the required proof may be drawn off, for denaturation only, from receiving cisterns in the cistern room of any distillery for transfer by pipes direct to any denaturing bonded warehouse on the distillery premises or to closed metal storage tanks situated in the distillery bonded warehouse or from such storage tanks to any denaturing bonded warehouse on the distillery premises, and denatured alcohol may also be transported from the denaturing bonded warehouse, in such manner and by means of such packages, tanks or tank cars, and on the execution of such bonds, and under such regulations as the Commissioner of Internal Revenue, with the approval of the Secretary of the Treasury, may prescribe. And further, alcohol to be denatured may be withdrawn without the payment of internal revenue tax from the distillery bonded warehouse for shipment to central denaturing plants in such packages, tanks or tank cars, under such regulations and on the execution of such bonds as may be prescribed by the Commissioner of Internal Revenue, with the approval of the Secretary of the Treasury.

Sec. 4. That at all distilleries producing alcohol from any substance whatever, for denaturation only, and having a daily spirit-producing capacity of not exceeding 100 proof gallons, the use of cisterns or tanks of such size and construction as may be deemed expedient may be permitted in lieu of distillery bonded warehouses, and the production, storage, the manner and process of denaturing of such alcohol, and the operation of such distilleries shall be upon the execution of such bonds and under such regulations as the Commisiosner of Internal Revenue, with the approval of the Secretary of the Treasury, may prescribe, and such distilleries may by such regulations be exempted from such provisions of the existing laws relating to distilleries as may be deemed expedient by said officials.

Sec. 5. That the provisions of this act shall take effect on September 1, 1907.

THE EFFECT OF THE CHANGE.

Section 1 of the law is of much importance. The Commissioner of Internal Revenue having held that no "liquid medicinal preparation" could be manufactured with the use of denatured alcohol under the original law, producers of smokeless powder, lacquers, enamels, &c., in which ether is used as a solvent, found themselves unable to secure the benefits of the free alcohol policy. The artificial silk industry, for the establishment of which in the United States a million-dollar corporation had been organized, was also denied the use of denatured alcohol, because of the fact that it is employed therein in the manufacture of ether, which, even when used for mechanical purposes, was held by the Internal Revenue Bureau to be barred as a "liquid medicinal preparation."

The provisions of Section 2 are relied upon to develop the industrial use of alcohol to a degree not heretofore contemplated. It will permit any manufacturer to establish a denaturing bonded warehouse and to transport thereto pure grain alcohol for his own use, thus saving the freight on the denaturing materials and the charge made by the distiller for the denaturing process. A manufacturer of brass goods, for example, may set apart one or two rooms in his establishment, transport thereto pure alcohol, denature it and use it in the manufacture of lacquers. Compared with the present cost of tax-paid grain spirits, fusel oil and other solvents for this purpose, it is estimated that the saving in the cost of lacquers will be not less than 50 per cent. and probably more. Hardware manufacturers, who use enormous quantities of enamels, metal varnishes, paints, &c., will enjoy the benefits of the amended law in a similar manner.

The general consumer of denatured alcohol will derive the greatest benefit from the provisions of Section 3. Under the original alcohol law the pure spirit was required to be drawn off into barrels before being removed to the denaturing warehouse, a tedious and expensive process, which is obviated by Section 3, which permits the spirit to be piped from one department to another, thereby saving not less than one-half cent a gallon, according to the estimates of the experienced distillers. The largest saving effected under this section, however, will grow out of the use of tank cars for transporting both pure grain spirits in bond and denatured alcohol without restriction. On this point the Ways and Means Committee, after careful investigation, embodied the following statement in their report upon the bill just enacted:

With reference to the economy of the tank car system, your committee has been advised that the railroads make no charge for handling empty tank cars back to the point of shipment. Their practice is to charge the same rate of freight as if the article was carried in barrels, and to make an allowance for mileage both coming and going. The charge for the freight and the payment of the mileage are two distinct transactions. When the article is shipped in barrels the weight of the barrels is included in the freight charges. When shipped in tank cars the weight of the tank is not included. Where empty barrels are returned to the point of shipment the rate of freight is in excess of the rate charged for the weight of such barrels when shipped to consumer, filled. It may, therefore, be safely stated that

alcohol, shipped in tank cars (since the barrels add at least three cents per gallon to the cost) will reduce the cost to the consumer at least 4 cents per gallon.

ESTABLISHMENT OF FARM DISTILLERIES.

Section 4 of the bill was enacted to permit the production of denatured alcohol on a small scale under conditions similar to those that have resulted in the establishment of nearly 8000 so-called farm distilleries in Germany. This feature of the bill is of interest from several different standpoints. The competition of the farmer in the manufacture of denatured alcohol will undoubtedly reduce its cost. The demand for small stills will build up an industry engaged in their production that will consume considerable quantities of metal. Perhaps the most important development will be the increased use of internal combustion engines and various types of small power agricultural machinery.

The Commissioner of Internal Revenue will immediately begin the preparation of an elaborate series of regulations for the enforcement of the amended law. This is a difficult and laborious task, as it will involve many changes in the internal revenue practice, even under the original alcohol law. It is expected that the new regulations will be promulgated about July 1, in order that producers, dealers and consumers may have at least two months to become thoroughly familiar therewith before the amendatory statutes go into force.—*Iron Age.*

Book Not ces

Jahrbuch für das Eisenhüttenwesen: (Ergänzung zu "Stahl und Eisen"). Ein Bericht über die Fortschritte auf allen Gebieten des Eisenhüttenwesens im Jahre, 1903. Im Auftrage des Vereins deutscher Eisenhüttenleute bearbeitet von Otto Vogel. 4ter Jahrgang. 464 pages, illustrations, 8vo. Düsseldorf, A. Bagel, 1906. Price, 10 marks.

This work contains a complete review of the iron industry during the year. We find an extensive bibliography covering all the branches of the iron trade, including statistics and a review of the patent literature.

There are articles on fuels and firing, on slags and ores, and the various kinds of iron; there is much information on the working of the metal and its properties. Some space is given to alloys and mixtures of iron and the work closes with a series of articles on the testing and examination of materials.

The index, authors and subjects in two parts, is very full and accurate.

Proccedings of the Chemical, Metallurgical and Mining Society of South Africa, with appendix. May, 1902 to June, 1903. Vol. 3. 483 pages, illustrations, plates, 8vo. Johannesburg, Transvaal, published by the Society. On sale at the office of the Engineering and Mining Journal in New York.

A great amount of work has been done during the year by this young society. We find a complete record of all the papers read and a full report

of the discussion of each. The addresses cover every branch of mining and metallurgy and go quite extensively into chemistry. The book closes with a department of notices and abstracts compiled from the world's periodicals.

The mining engineer will find the volume interesting as an indication of progress in England's youngest colony.

Cyclopedia of Applied Electricity: A practical guide for electricians, mechanics, engineers, students, telegraph and telephone operators, and all others interested in electricity. Prepared by a corps of experts, electrical engineers and designers. Illustrated with over two thousand engravings. 5 vols., 4to. Chicago, American School of Correspondence at Armour Institute of Technology, 1905.

This work is made up of a series of articles written by well-known experts and covering the entire field of electricity. Volume I contains the elements of electricity, a chapter on the electric current, articles on measurements and wiring and the telegraph. Volume II is devoted to dynamos, motors and storage batteries. Volume III contains lengthy articles on electric lighting, railways and power stations. Volume IV, alternate currents and power transmission. Volume V is devoted entirely to the telephone. The writers and collaborators number seventeen, and the authorities consulted twenty-seven. The work will appeal chiefly to the artisan who is devoting his spare time to the study of the practical side of electricity.

L'Industrie Oléicole (Fabrication de l'Huile d'Olive) par J. Dugast. 176 pages, illustrations, 12mo.

Préparation Mécanique des Minerais. Resumé pratique par F. Rigaud. 171 pages, illustrations, 12mo.

Les Petits Métaux. Titane, Tungstène, Molybdène par a Truchot, 189 pages, 12mo.

Construction des Induits a Courant Continu. Partie Mecanique par E. J. Brunswick et M. Aliamet, 173 pages, illustrations, 12mo.

Construction des Induits a Courant Continu. Manuel pratique de bobinier par E. J. Brunswick et M. Aliamet. 153 pages, illustrations, 12mo.

Rivetage par M. Fricker. 168 pages, illustrations, 12mo., Paris, Gauthier-Nillars, n. d.

The above volumes are the latest additions to the well-known series Encyclopédie Scientifique des Aide—Mémoire issued under the editorial direction of M. Léauté. The books are uniform with previous issues and form valuable monographs on the subjects to which they relate. The price per volume is two francs, 50c., in paper, and three francs in cloth. R.

La Ionizzazione e La Convezione Elettrica Nei Gas. By Lavoro Amadiozzi. 368 pages, illustrations, 8vo. Bologna, Zanichelli, n. d. (Attualita Scientifiche, No. 9.)

In a letter preserved in the British Museum, Robert Bowning says: "I never pretended to offer such literature as should be a substitute for a

cigar or game at dominoes to an idle man." There are some scientific books which lead one to think that the authors were afraid of being found guilty of having written an interesting volume. The author of the above book is not fearful of this aspersion, in fact in his preface he acknowledges that he desires his book to be "plain and elementary." This commendable program is well carried out. The book is up to date. It treats in a lucid manner of the kathode, the canal and the X Rays. The treatment of the complicated phenomena which manifest themselves when a current is sent through rarefied gases seems to be admirable. The matter of the ionization of gases comes in for a full share of treatment. The Zeeman Effer and the Doppler effect in anode rays are also discussed.

It is pleasant to note that the workers of the United States and of Canada are frequently quoted,—Rutherford, McClung, McClelland and Zeleny, though how would it be possible to write a book on this subject and not mention them? The author refers modestly to his own work on the electric spark.

The general arrangement of the book is excellent. Each section has a title in heavy type at its beginning. The figures are clear and do not suffer from too much detail. The printer has done his part well. A bibliography of 154 numbers is a valuable addition.

Just a few words of criticism. A little more care might have been exercised in the spelling of proper names. McClung and McClelland appear as MacClung and MacClelland. C. Barus loses his identity as E. Barus. Phil. Trans becomes at the foot of page 360 Phis. Trans. These are but minor blemishes that would not be noticed in a less excellent book, but the omission of a comprehensive index is a defect that makes the book far less usable. Let us hope the second edition will have a worthy index.

The author is to be congratulated on having produced an excellent book upon one of the living themes of physics. G. F. S.

The Steam Engine and Other Heat-Motors, by W. H. P. Creighton, U. S. N. (Retired). First edition, first thousand. 499 pages, illustrations, 8vo. New York, John Wiley & Sons, 1907. Price in cloth, $5.00.

This very excellent work treats the elementary principles of the steam engine and other heat motors and the various forms of energy in a clear, terse and comprehensive way, that will doubtless interest that advanced class of students for whom it is intended. The work itself is a valuable addition to extant literature upon this subject and should be cordially welcomed by all those interested in this field of investigation and study.

C. E. R.

Hygromedry, by Henry Emerson Wetherill, M. D. 4th ed., rev. and enl. 82 pages, illustrations, oblong, 32mo. Philadelphia, published and illustrated by the author, 1906. Cloth, price, $2.50.

Dr. Wetherill has had considerable experience as a medical practitioner in private life and a surgeon in the army. In connection with his various

medical duties he has been constantly devising new instruments to assist the physician in his work.

In the book before us he describes in detail what is perhaps his most important invention: The Hygromed, an instrument for the measurement of the moisture of the body. In the supplementary pages we find brief descriptions of Dr. Wetherill's other devices. R.

Augosto Righi. La Moderna Teoria dei Fenomeni Fisici. (Radioattivita, Ioni, Elettroni) Ed. 3, considerably enlarged. 290 pages, illustrations. 8vo. Bologna, Ditta Nicola Zanichelli, 1907. Price, paper, 5 lire.

We have in this book a complete review in simple, lucid style of the electron theory, its many applications in the various branches of physics and the readjustment of the modern ideas to conform to this theory.

The whole is concluded with a bibliography containing one hundred and ninety-nine references.

The book is issued in good style as No. 3 of the series "Attualita Scientifiche."

Concrete Factories. An illustrated review of the principles of construction of reinforced concrete buildings, including reports of the Sub-Committee on Tests, the United States Geological Survey and the French rules on reinforced concrete. Compiled by Robert W. Lesley. 152 pages, illustrations, 8vo. New York, published for the Cement Age by Bruce & Banning, n. d. Cloth, price, $1.00.

There is already a number of books on reinforced concrete, but the present work deals more especially with the subject of factory buildings. The compiler is editor of the Cement Age, and is thoroughly familiar with the needs of the modern architect.

The work contains a review of the principles underlying reinforced concrete construction in clear and concise language.

There are reports of tests of various government committees and boards and a complete text of the French rules for the design of structures in reinforced concrete.

Nearly all the cement experts have contributed articles, making the book extremely useful. The illustrations are appropriate and interesting. We would suggest that a complete index be included in the next edition, this would make the book still more useful. R.

Notes on Mechanical Drawing, prepared for the use of students in mechanical drawing at the University of Pennsylvania, by Horace P. Fry, B.S. in E.E. 55 pages, illustrations, 8vo. Philadelphia, printed for the University, 1905.

This work is intended as a hand-book to be used by the students of the University in connection with their class work. It is not an exhaustive treatise on the subject, but a reference book containing hints, tables and other information in use among American draughtsmen. There are already many treatises and hand-books on drawing, but this latest arrival will undoubtedly be well received by engineering students. R.

The Steel Square as a Calculating Machine, being simple directions for using the common steel square for the solution of complicated calculations that occur in the everyday work of carpenters, builders, lumber dealers, plumbers, gas fitters, engineers, electricians, tinsmiths, blacksmiths, masons, stone cutters, etc., with numerous illustrations, by Albert Farr. 81 pages, illustrations, 12mo. New York, Industrial Publication Company, 1906. Price, 50 cents.

This latest work on the slide rule is intended for the mechanic, and is written in simple language without mechanical terms. It describes the use of the square for the solution of the many problems which present themselves to carpenters, machinists and others in the course of their work. R.

Untechnical Addresses on Technical Subjects, by James Douglas, LL. D. 84 pages, 12mo. New York, John Wiley & Sons, 1904. Price, $1.00.

Three addresses are included in this book, the first on "The Characteristics and Conditions of the Technical Progress of the Nineteenth Century." the second on "The Development of American Mining and Metallurgy and the Equipment of a Training School;" the third on "Wastes in Mining and Metallurgy."

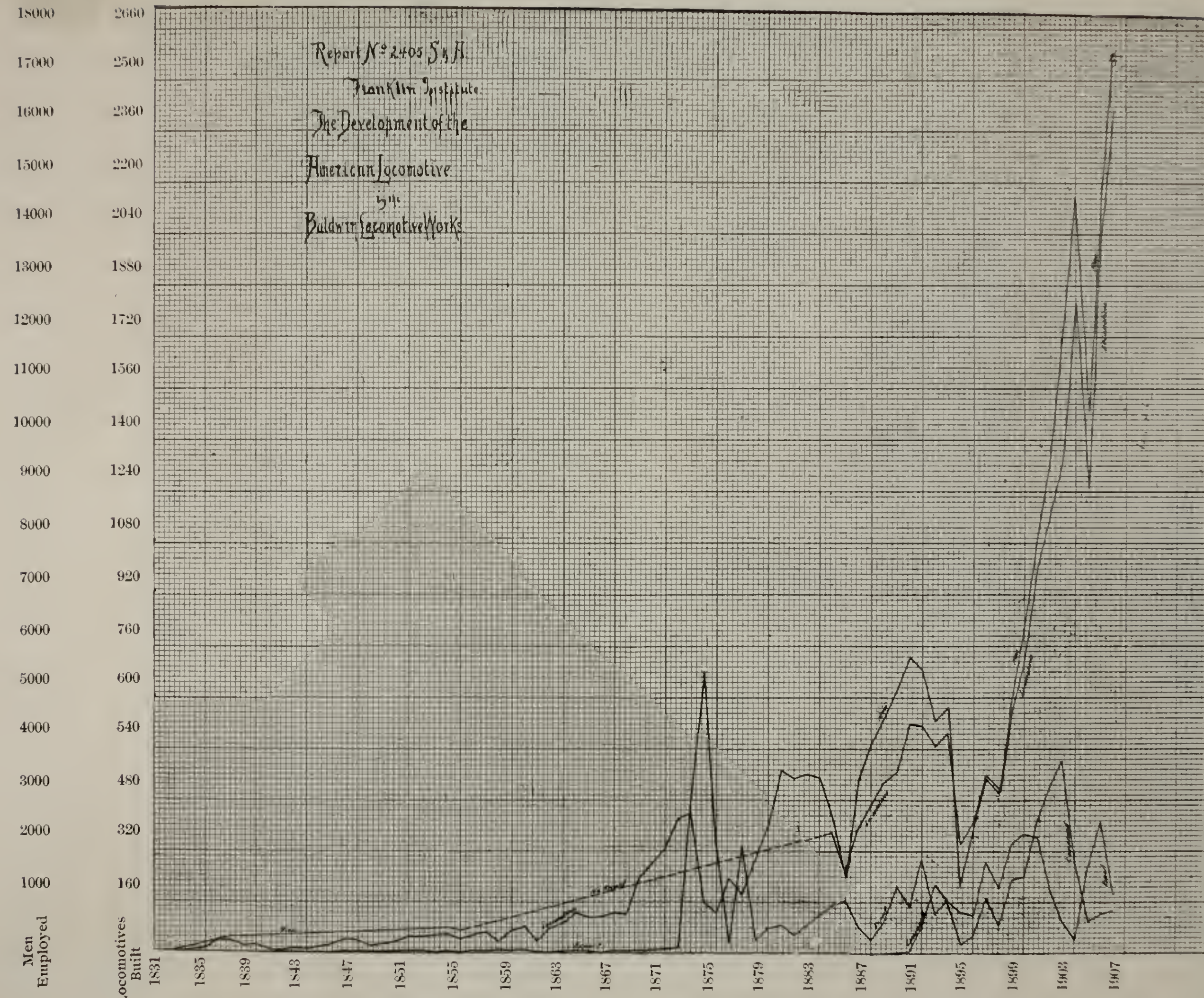
The addresses are popular in character and make interesting reading. R.

Fortschritte in der Anwendung der Röntgenstrahlen von Dip-Ing. Dr. phil. Josef Rosenthal, München. 31 pages, illustrations, 8vo. München, J. F. Lehmann's Verlag, 1906. Paper, price, 1.20 mark.

This pamphlet is a reprint of an address delivered by Dr. Rosenthal before the Society of Natural History of Munich. It is a resumé of the ten years' work with the Xrays put in plain words to meet the needs of the average reader. R.

Aide-mémoire de Photographic pour 1903 publié sous les auspices de la Société Photographique de Toulouse par C. Fabre. 28me année, troisieme serie, tome VIII. 299 pages, illustrations, 24mo. Paris, Gauthier-Villars, n. d., paper, price, 1.75 franc.

This annual contains a review of progress in the various branches of photography. The contents include a directory of the photographic societies of the world, a list of patents granted in France during the year relating to photography, many exposure tables, formulæ, a bibliography and much other matter of value and interest to the photographic worker. R.


Report No 2405 S & A.
Franklin Institute.
The Development of the
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Baldwin Locomotive Works
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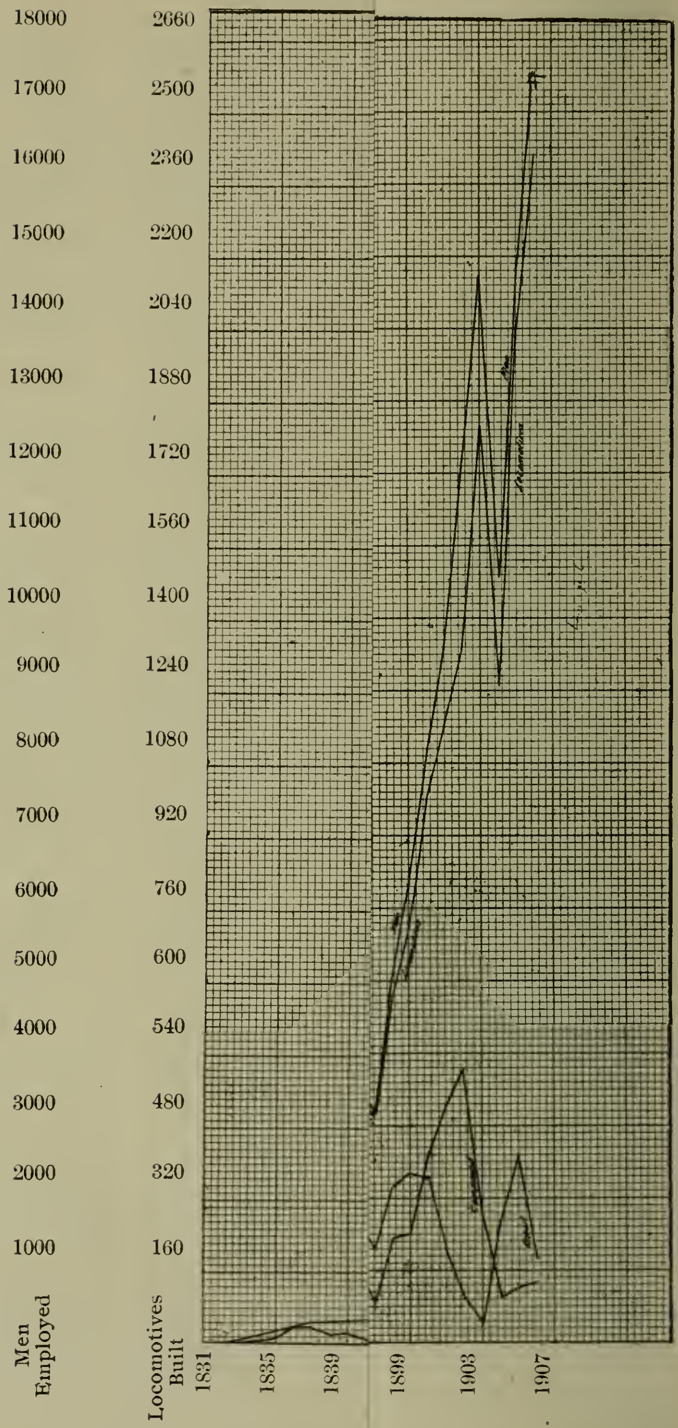
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Locomotives Built
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1835
1839
1899
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1907

JOURNAL

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OF THE STATE OF PENNSYLVANIA

FOR THE PROMOTION OF THE MECHANIC ARTS

VOL. CLXIV, No. 4 82ND YEAR OCTOBER, 1907

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THE FRANKLIN INSTITUTE.

The Development of the American Locomotive.

(*Being the report of the Committee on Science and the Arts on the Contribution of the Baldwin Locomotive Works. Sub-Committee:* Charles E. Ronaldson, Chairman; T. Carpenter Smith, Arthur Falkenau, Strickland L. Kneass.)

(No. 2405)

The Franklin Institute, acting through its Committee on Science and the Arts, investigating the "Development of the American Locomotive," as exemplified in the Baldwin Locomotive Works, of Philadelphia, reports as follows:

The most striking example of a purely Philadelphia institution, in which her citizens take a just patriotic pride and which stands pre-eminently typical of careful systematic management is the venerable and justly renowned Baldwin Locomotive Works.

Founded in 1831, in an extremely modest way, they have forged ahead (though encountering many vicissitudes and setbacks) until to-day they are foremost, commanding the respect and admiration of the world.

From their first locomotive, which consumed over a year to complete, they are to-day turning out nearly fifty-two completed engines every week, while it is fair to presume that even this

great number may increase in the near future. The problems of maintenance, production and management, intricate and perplexing, have all been satisfactorily solved, and to-day these vast works operate systematically and smoothly without apparent friction of any sort whatever.

During the seventy-five years and over of their existence, they have kept abreast of the rapidly increasing requirements of the railroads throughout the civilized world, while in later years when the demand for electrical engines developed we find these works turning out a product second to none; and when the compound locomotive came into vogue, these works were quick to take hold of and produce their own type of this class of engine.

In the process of evolution from the first crudely constructed locomotive, the American type developed, having four driving wheels and a four-wheeled truck; then followed the ten-wheeler; then the "Mogul," "Consolidation," "Mastodon," "Decapod," "Atlantic," "Mikado," "Prairie," "Pacific," and "Santa Fe" types, besides a great variety of locomotives of different gauges and for different kinds of service, representing current requirements.

The Letters Patent owned and controlled by this company are "legion" in point of numbers, so that it is imposisble to enumerate all of them, the Committee confining themselves to those that were esesntial to the efficiency of the American Locomotive as exemplified to-day.

A distinguishing feature which characterizezs the means for securing absolute uniformity of the essential detail parts of all locomotives of the same class, is the use of standard gauges and templates, which has resulted in the formation of the "Department of Standard Gauges," which is looked after by a special foreman and an adequate force of skilled workmen, it being recognized many years ago that like parts of similar engines should be absolutely uniform and interchangeable, which results in insuring to the purchaser a minimum cost for repairs and rendering possible by this method the extraordinarily increasing output of these works. This department contains standard gauges and templates of every description of work to be done. The original templates are kept as "Standards," and are never used upon any work itself, and from them exact duplicates are made and used and to which all work is required to conform. The working

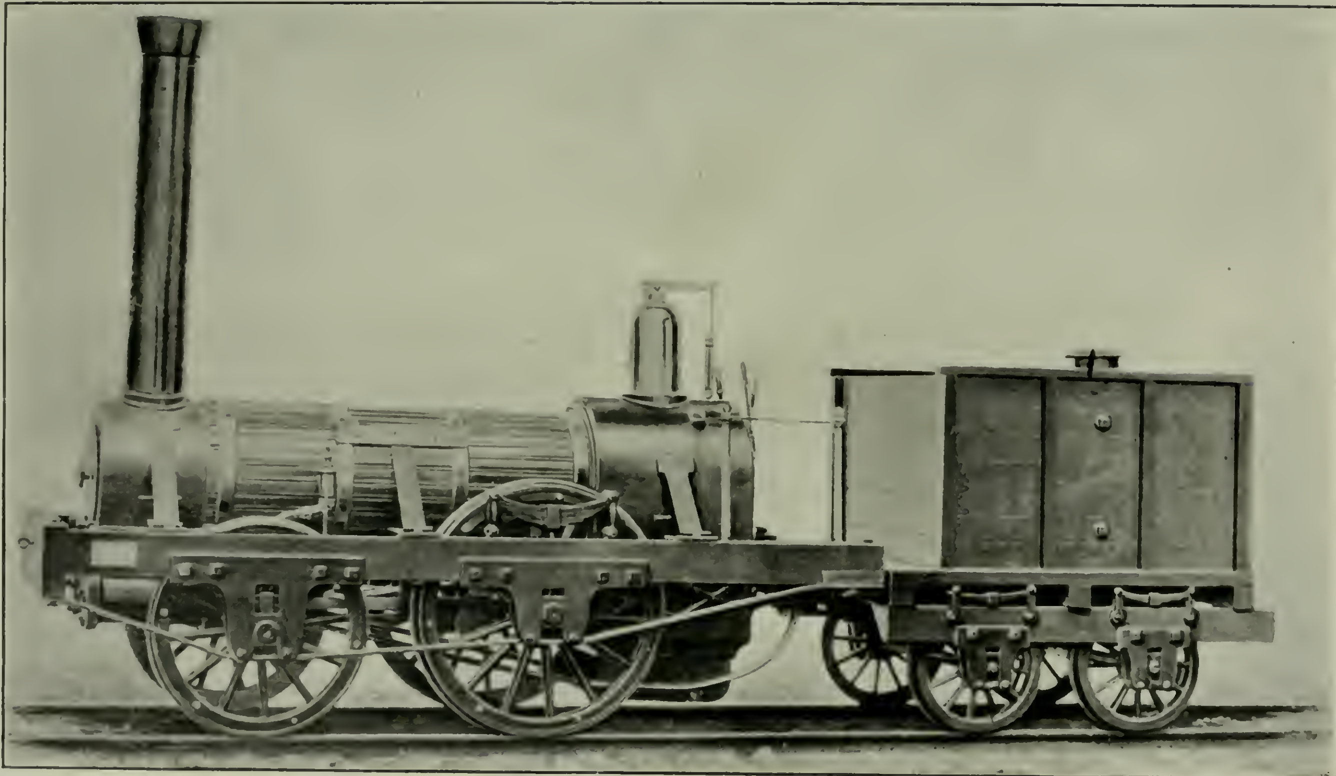

Fig. 0.—"Old Ironsides."

gauges are compared to the "Standards" at regular intervals, thus maintaining absolute uniformity for every possible important detail of construction.

Matthias W. Baldwin was born in Elizabeth, N. J., on December 10, 1795. He was elected Vice-President of the Franklin Institute in 1855. He learned the trade of a jeweler, and was in the service of Fletcher & Gardiner, silversmiths and jewelers, until about 1819, when he began business for himself, opening a small shop upon similar lines. In 1825 he formed a partnership with David Mason, a machinest, manufacturing bookbinders' tools and cylinders for calico printing. Their business prospered. steam power became necessary; the engine they bought proving unsatisfactory, Mr. Baldwin designed and built an engine suitable to their requirements, which in a short while proved so efficient that he received orders for additional ones. This original "upright" stationary engine, built prior to 1830, is still in good order and carefully preserved at the works. Thus, Mr. Baldwin became interested in the manufacture of stationary engines. Steam as a motive power on railroads engaged the attention of American engineers in 1829-30; a few locomotives having been imported from England, and one was built at the West Point Foundry, in New York. In 1831, Mr. Baldwin completed a miniature locomotive, for Mr. Franklin Peale, for exhibition in his museum. The success of the model was such that Mr. Baldwin received his first order for a locomotive from the Philadelphia, Germantown & Norristown Railroad Co. In those early days it was almost a superhuman task to undertake such a work. Mechanics were very few; suitable tools could hardly be obtained, cylinders had to be bored with a chisel fastened in a block of wood, while blacksmiths who could weld bars of iron exceeding $1\frac{1}{4}$ inches square were exceedingly few, or not to be had. Therefore, Mr. Baldwin had to do most of the work himself in order to educate the men who assisted him to fashion the necessary tools for the various processes. The work was prosecuted notwithstanding and the locomotive completed and tried on November 23, 1832. This was the famous "Old Ironsides." Thirty men were employed at this time.

In the second locomotive built the valve motion was actuated by a fixed eccentric for each cylinder, the straps of each had two arms attached, one above, one below, the driving axle being back

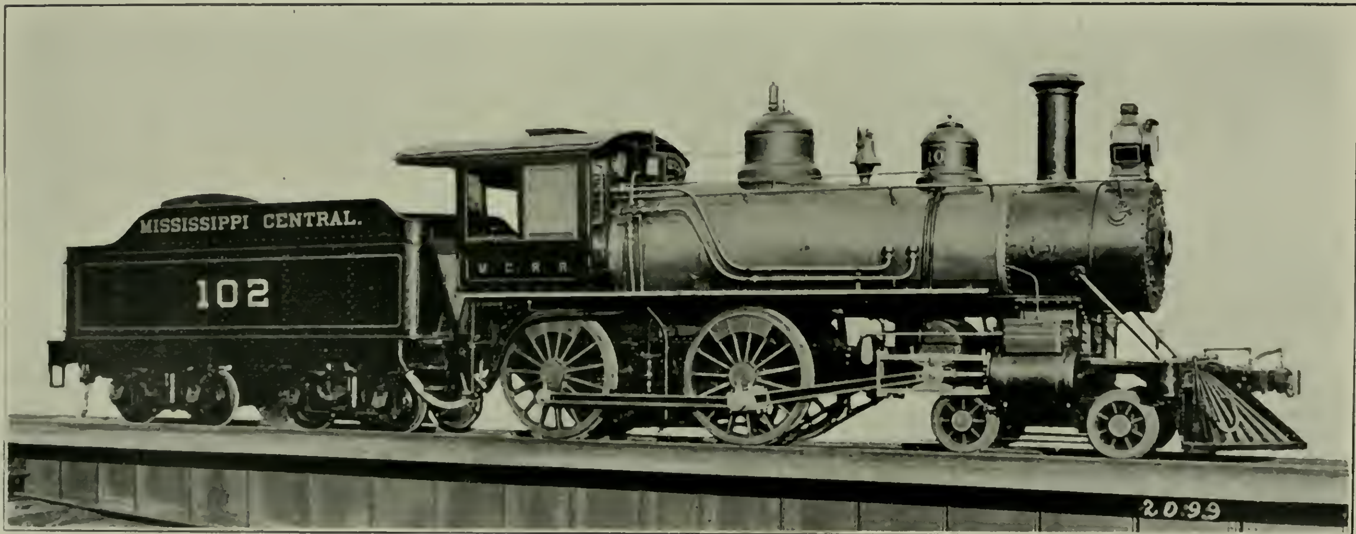

Fig. 1.—"American Type."

of the fire-box, these arms were prolonged backwards under the footboard, with a hook upon the inner side of the end of each; the rock-shaft had arms above and below its axis and the hooks of the two rods were moved by hand-levers, to engage with either arm, thus producing forward or the reverse motion. In 1834, five locomotives were completed, and the shop becoming too small for the increasing business, a new shop was erected at Broad and Hamilton Streets, and the business removed to it in 1835. The important devices adopted and employed in these early engines, being the result of Mr. Baldwin's study and experiments, were patented in 1834, and the same patent covering the following inventions, viz.:

1. The Half Crank.
2. New Method of Constructing Wheels for Locomotives and Cars.
3. New Mode of Forming Joints of Steam and other Tubes.
4. New Mode of Forming Joints and other parts of the Supply Pumps and of Locating the Pump Itself.

This last claim consisted in utilizing the hollow guide bar and making it do duty as the pump-barrel, the plunger of which was attached to the piston rod. Mr. Baldwin laid great stress upon the position of the driving wheels by placing them back of the fire box; thus throwing one-half the weight upon them and one-half upon the four-wheeled truck, thus extending the wheel base and producing steadiness and less track damage.

The application of ground steam joints in the steam pipes added greatly to the success of his early engines, and this manner of grinding the joints is now universally used. In 1839, Mr. Baldwin bought the E. L. Miller patent, this being a method of increasing the adhesion of the locomotive by throwing the weight of a part of the tender upon the rear of the engine.

In the early part of 1835, the new Broad Street shop was completed and occupied. On April 3, 1835, Mr. Baldwin took out a patent for certain improvements in the wheels and tubes of locomotives. That for the wheel related to casting the hub and spokes together and having the spokes terminate in segments of a rim. The improvements in tubes consisted in driving a copper ferrule or thimble upon the outside end of the tube. The object was to make a tight joint with the tube sheet and the advantage gained by the outside ferrule strengthened the

(Baldwin Locomotive Works.)

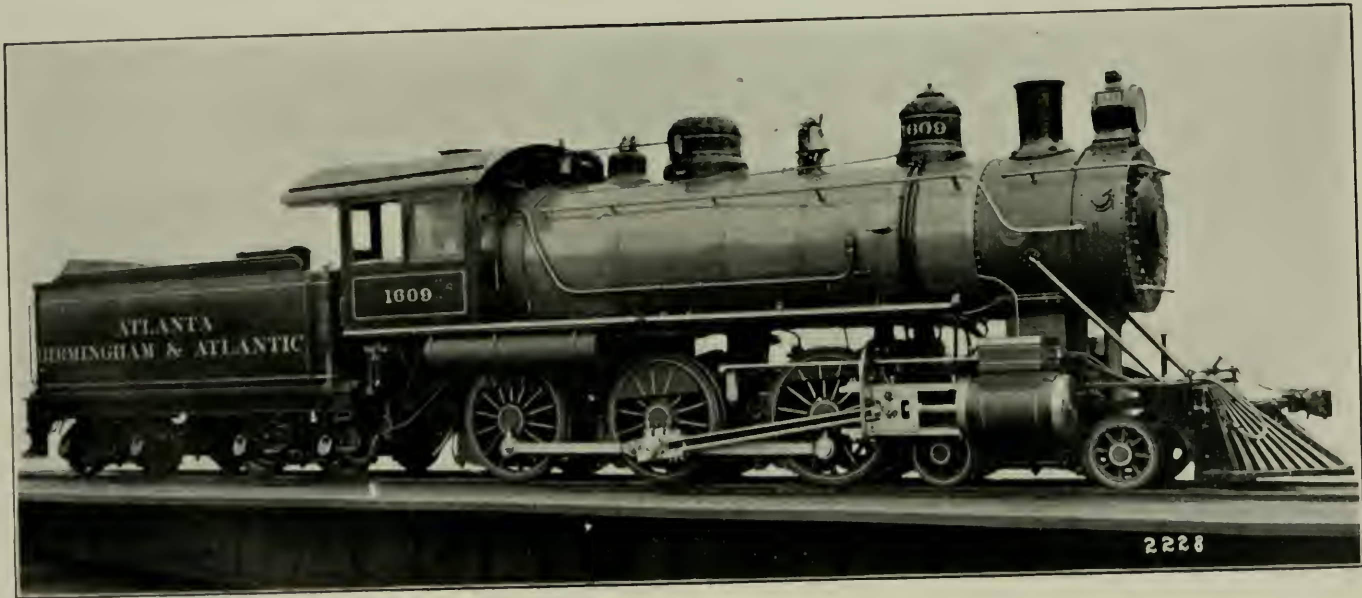

Fig. 2.—"Ten-Wheel Type."

tube and made a tight joint with the sheet. It left the tube free and unobstructed its entire length. This patent proved extremely valuable, and the method is now generally used.

In this year the first outside-connected locomotive was built, and it embodied the Miller device and was put in service upon the Philadelphia & Trenton Railroad.

In 1835, 14 engines were constructed.
" 1836, 40 " " "
" 1837, 40 " " "
" 1838, 23 " " "
" 1839, 26 " " "
" 1840, 9 " " "
and 300 men were employed.

The average weight of these locomotives was between 20,000 and 26,000 pounds. The number of men employed was 300, yet this force was reduced weekly, the demand for engines rapidly falling off in 1838, as will be seen from the above table of annual production.

In the latter part of 1839, the old wooden frame disappeared, the machinery truck and pedestals of the driving boxes were attached to an iron frame which took its place, and we find that eight-wheel tenders were first being used about this time.

In 1842, Mr. Baldwin secured a patent for his flexible truck, which contributed more than any of his subsequent patents or inventions to the foundation of his fortune, and led to the construction of his well-known six-wheel connected locomotive, which had the four front drivers combined in a flexible truck; the rear wheels were rigidly placed in the frame, behind the fire box, with inside bearings. The action of the flexible beam was such that the engine in passing a curve the middle pair of drivers could move laterally in one direction, say to the right, while the front pair would swing in the opposite direction, or, to the left, the two axles remaining parallel to each other and to the rear driving axle. The operation resembled that of a parallel ruler; on a tangent the axles and beams formed a rectangle, on a curve, a parallelogram. We call attention to this flexible truck patent, as it was fundamental to the future development and perfection of the Baldwin locomotive.

Journal Franklin Institute, vol. clxiv, October, 1907.

(Baldwin Locomotive Works.)

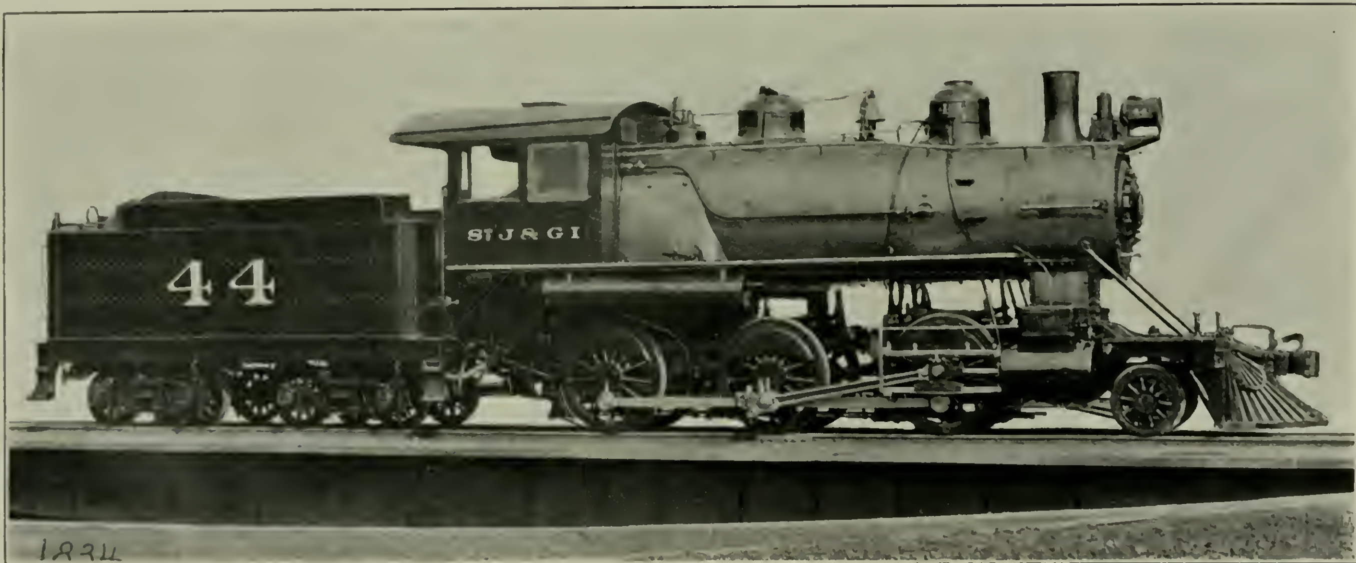

Fig. 3.—"Mogul Type."

In 1842, 14 locomotives were constructed.
" 1843, 12 " " "
" 1844, 22 " " "
" 1845, 27 " " "
" 1846, 42 " "
" 1847, 39 " " "
" 1848, 20 " " "
" 1849, 30 " " "
" 1850, 37 " " "
" 1851, 50 " " "
" 1852, 49 " " "
" 1853, 60 " " "
" 1854, 62 " " "
and 500 men were employed.

The performance of the first locomotive using the flexible truck excited widespread interest. The weight of the engine was but twelve tons, its haul was 250 tons, upon a grade of thirty-six feet per mile.

In 1842, the method was used of giving to each type of locomotive a distinct classification, composed of a number and a letter, besides systematizing many details in their management of the business.

Mr. Baldwin first used iron flues or tubes in 1844, and the advantage found was in the fact that the iron flue sheets and iron tubes expanded alike, while the unequal expansion of iron sheets and copper flues caused leakage. Link motion was first applied in 1845, and also the "half stroke cut off." The present design of four drivers and a four-wheeled truck was first adopted by Mr. Baldwin in 1845. In 1846, an eight-wheel connected type of engine was built, and at this time the wooden cab with sash and glass was added, and made for the Baltimore & Ohio Railroad. In 1847, rocking grate bars were introduced, and the first "rack" locomotive was built. In 1848, steel axles were first used. Fast-speed passenger locomotives were able to travel sixty miles an hour. In 1849, outside-connected engines were built almost exclusively. In 1850, the wagon-top boiler superceded the old dome boiler, which had been in use since 1834.

In 1852, the ten-wheel engine was placed in the Baldwin classification, yet not until 1860 did this type of engine wholly super-

(Baldwin Locomotive Works.)

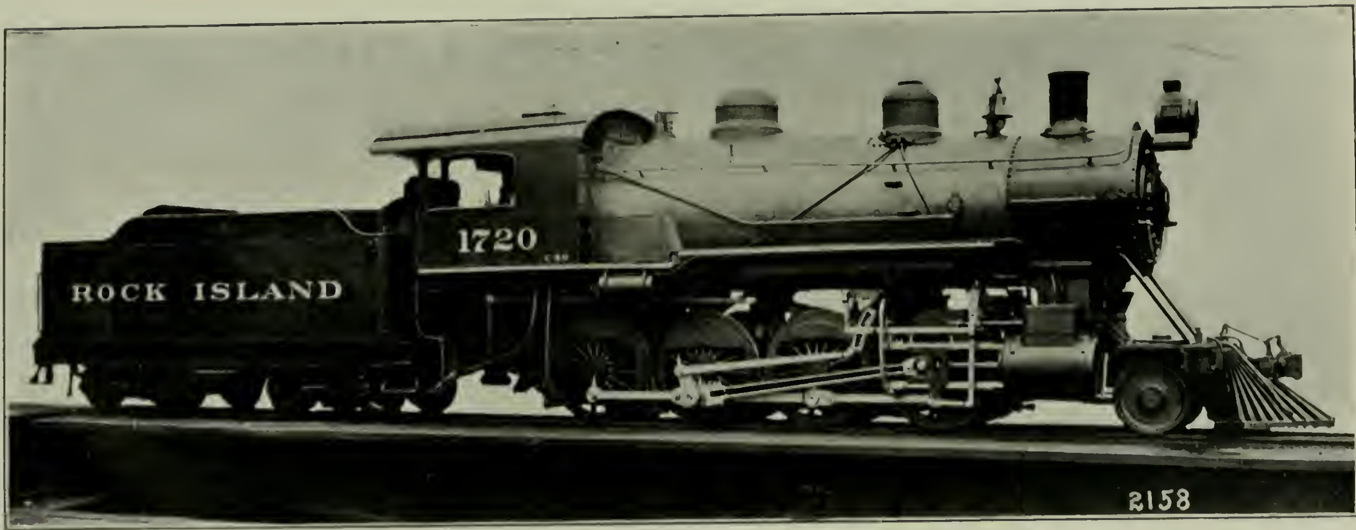

Fig. 4.—"Consolidation Type."

sede the old pattern of six-or eight-wheel connected. In this year, Mr. Baldwin patented his "variable cut off," which device never came into general use. Link motion, however, was generally introduced at this time and rapidly gained in favor, and in 1857, it was adopted exclusively. Fire brick arches in the fire box were used and adopted about this time, supported on side plugs. In 1858, water pipes extending obliquely from the crown down and curving to the sides of the fire box at the bottom were used.

The adoption of the link-motion clearly marks the dividing line between the early experimental and the present locomotive practice. Changes since then have been made, but in detail principally, yet it has been in the perfection of these details that we have to-day the efficient, symmetrical, complete piece of mechanism which stands out as one of the greatest tributes to the ingenuity of man. To-day, one can hardly realize the almost insurmountable difficulties which have been overcome to bring the locomotive to its high efficiency, and in perfecting all this the Baldwin Locomotive Works has had no small share in its success.

In 1855, 47 engines were completed.
" 1856, 59 " " "
" 1857, 66 " " "
" 1858, 33 " " "
" 1859, 70 " " "
" 1860, 83 " " "
and 430 men were employed.

The greater number of these locomotives were of the ordinary American type, four drivers, four-wheeled truck, varying in weight from fifteen to twenty-seven tons. A few ten-wheeled engines were built, the remainder being the flexible truck with six and eight-wheels connected. The demand for these was rapidly falling off, the ten-wheeled and heavy four-wheel connected and four-wheeled truck engines were taking their place, and by 1859, they ceased to be built, save in exceptional cases for export. Intense interest was taken at this time in the proper means to be employed in combustion. Various experiments were tried in the fire boxes. The result of study and experiment led Mr. Baldwin to the conclusion that the ordinary form of boiler, with plain fire box, was right, with, perhaps, the addition of the

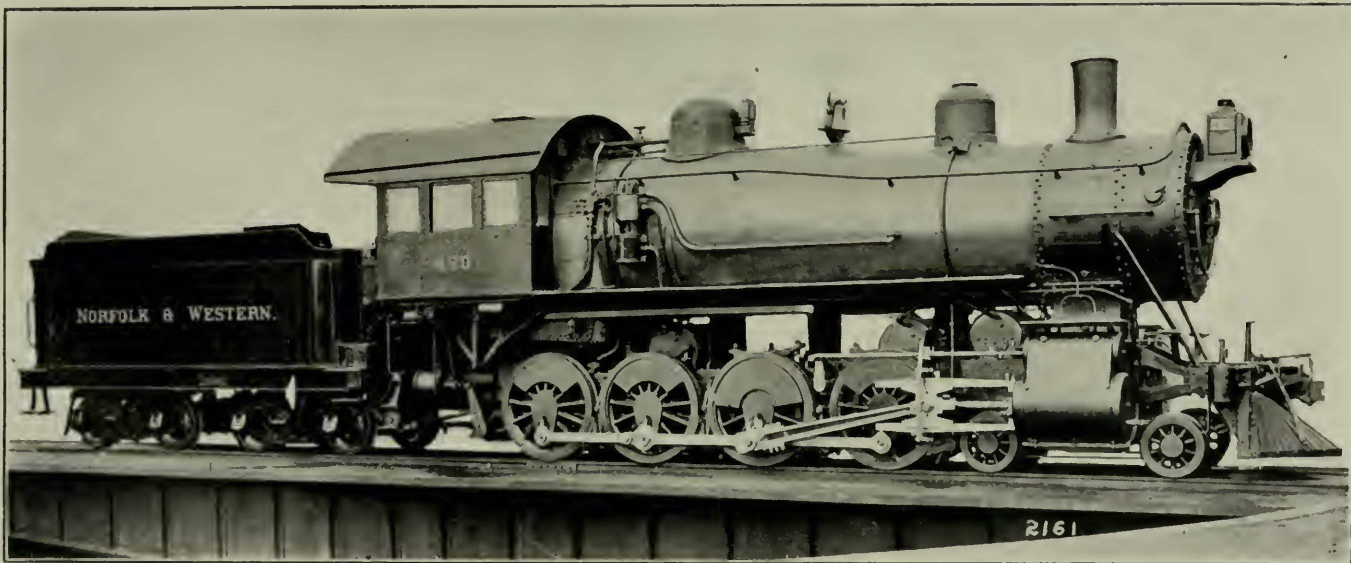

Fig. 5.—"Mastodon Type."

fire brick arch; that the secret of successful and economical use of coal was in the manner of firing, rather than in any particular design of fire box.

The breaking out of the Civil War unsettled trade, and a notable falling off in building occurred.

In	1861,	40	locomotives	were	built.
"	1862,	75	"	"	"
"	1863,	96	"	"	"
"	1864,	130	"	"	"
"	1865,	115	"	"	"

In 1861, eighteen-inch cylinder freight locomotives with six wheels connected, with a pony-truck were built. This is the first instance of the use of the "Pony" truck in these works.

The introduction of steel in locomotive construction became a distinguishing feature at this time, and steel has gradually replaced wrought iron, etc., for tires, fire-boxes, and boilers. Another distinguishing feature at this time was placing the cylinders horizontal. Casting the cylinder and the half saddle in one piece, and fitting it to the circular smoke-box was designed by Mr. Baldwin. He was the first builder to adopt an outside cylinder, with a circular flanged segment cast to it, in order to be bolted to the boiler. The advantages of this arrangement are simplicity, strength and economy. The cylinders can be used for rights and lefts, one pattern answers for either. From high inclination the cylinders were gradually brought to less until the horizontal position was attained and maintains to-day.

In	1866,	118	locomotives	were	built.
"	1867,	127	"	"	"
"	1868,	124	"	"	"
"	1869,	235	"	"	"
"	1870,	280	"	"	"
"	1871,	331	"	"	"

In 1866, the "Consolidation" type came into use, the first engine being the "Consolidation," built for the Lehigh Valley Railroad Company. It had four pairs of drivers connected and a Bissell-Pony Truck. The following year (1867) the "Mogul" class of engine, with three pairs of drivers connected and a swinging pony-truck took its rise in the practice of these works

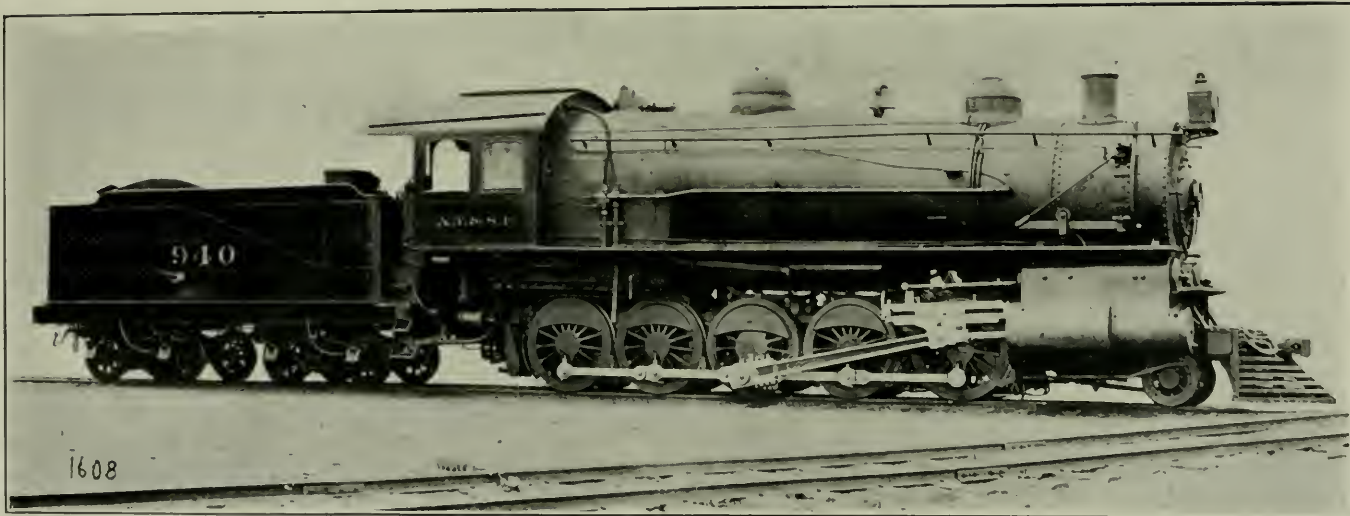

Fig. 5a.—"Decapod Type."

from the "E. A. Douglas," built for the Thomas Iron Company, and this plan of engine has rapidly grown in favor for freight duty upon grades and where heavy loads are to be carried.

Steel flues were first used in ten-wheel freight engines in 1868, and also steel boilers the same year. The 1854 type of engine having a straight boiler and two domes was revived in 1866, and until 1880 both the straight and wagon top boilers were built; yet since 1880 the two domes have been seldom specified. The first narrow gauge locomotive ($3\frac{1}{2}$ ft.) was built in 1868. The decade 1870-1880 witnessed the introduction of several improvements. In June, 1871, a double-ender locomotive was designed for suburban service on the Central Railroad of New Jersey. This was the first engine to have a truck with side bearings. These were used on the rear truck, which had four wheels.

In 1878, a locomotive driver brake, operated by steam, was introduced by these works. This brake was operated by a slide valve, which was replaced in 1882 by an improved form of disc valve. When required the brake was arranged for application to tender as well as driving-wheels. The equalized tender brake on both trucks was first used in 1872, by the Baldwin Locomotive Works. Locomotives for single-rail lines were built in 1878-79.

A locomotive for a gold mine in California was built in 1876, the gauge being but twenty inches. Steel tires were first shrunk on without being secured by bolts or rivets in any form in 1870, and now this is the prevailing custom.

In 1872,	422	locomotives	were	built.
" 1873,	437	"	"	"
" 1874,	162	"	"	"
" 1875,	130	"	"	"
" 1876,	232	"	"	"

and nearly 3,000 men employed.

A small locomotive operated by compressed air was built in 1875. During the year 1876, a new departure in locomotive engineering in these works took place—an experimental steam street car was built, which, proving in a great massure a success, the next step was the construction of a "Motor" car, to which one or more ordinary cars could be attached. Steel fire boxes with

(Baldwin Locomotive Works.)

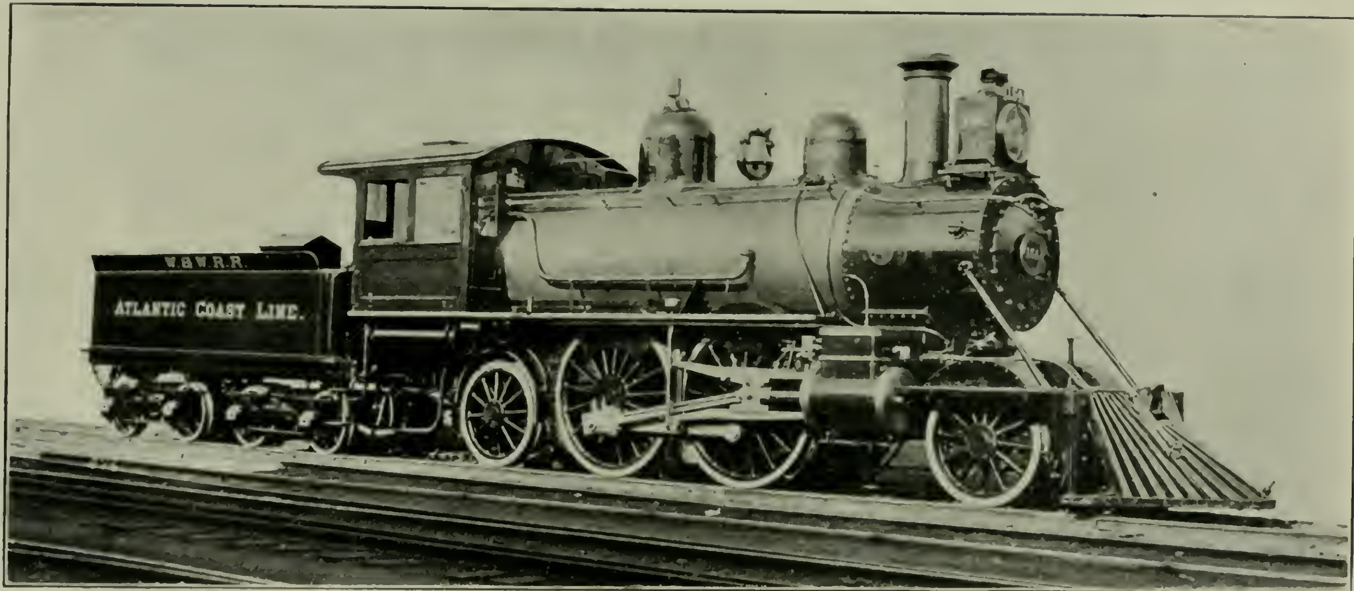

Fig. 6.—"Columbia Type."

vertical corrugations in the side sheets were first made by these works in 1876.

In 1885, the "Decapod" locomotive was built, having ten-wheels connected, with a "Pony" truck. A locomotive was constructed during the year 1886, having an outside frame. In 1887, a new form of boiler was built. An extended wagon-top was used, extending, to allow the dome to be placed in front of the fire-box, near the center of the boiler having the crown sheet supported by radial stays from the outside shell. Many boilers of this type have since been consructed. These works have also taken an active part in the development of the "Wootten" boiler, in its original and modified forms. They were the first to place the grate above the frames and thus use all the space between the wheels for the width of the fire-box. The first locomotive for Japan was shipped in June, 1887.

During 1888-89, an active demand sprung up for steam motors for street railway service, and ninety-five of them were built; also, two rack-rail locomotives of the "Riggenbach" system for foreign locomotive service were built.

In October, 1889, the first compound locomotive was completed. It was the four-cylinder type designed and patented by Mr. S. M. Vauclain, then the general superintendent of the works. That they came rapidly into use is evidenced by the fact that in the year 1889 one was built.

In 1890,	3	were	built.
" 1891,	82	"	"
" 1892,	213	"	"
" 1893,	160	"	"
" 1894,	30	"	"
" 1895,	51	"	"
" 1896,	173	"	"
" 1897,	86	"	"
" 1898,	235	"	"
" 1899,	241	"	"

Records show that the first cast-steel driving wheel centers were used in France in the year 1890. The Baldwin Locomotive Works began their use in 1891, and thus early availed themselves of this improvement.

In 1889, a test was made to see in how short a time a locomo-

Journal Franklin Institute, vol. clxiv, October, 1907.

(Baldwin Locomotive Works.)

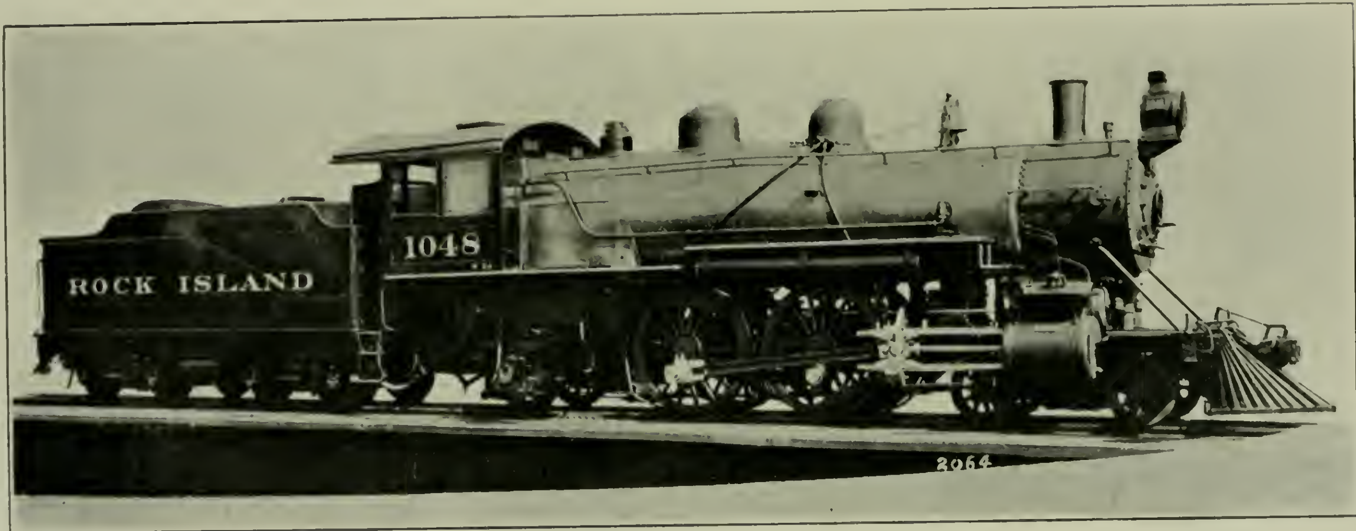

Fig. 7. "Atlantic Type."

tive could be built. The order was given upon June 22nd, for a narrow gauge locomotive, "American" type, for passenger service and upon July 2nd it was completed, having consumed but eight working days from the raw material.

In this year, the manufacture of wrought iron wheel centers for both truck and driving wheels was begun, under patents of Mr. Vauclain.

In 1890, the first rack-rail locomotive under the "Abt" system was constructed for the Pike's Peak Railroad Company, and during this year and 1893, four locomotives of this type were built for this road, the grades varying from 8 to 25%.

Three "Mogul" type locomotives of one metre gauge were built and shipped to Palestine in 1890.

In 1891, the largest locomotives in the history of the works were designed and built for service in the tunnel under the St. Clair River, of the Grand Trunk Railway. They were ten-wheel connected with tanks on the boiler and weighed each, in working order, without fire, 186,800 lbs. Five compound locomotives of the "Decapod" pattern were built for the Erie Railroad.

The first locomotives for Africa they built this year. They were of the "Mogul" type, for 3 ft. 6 in. gauge.

In 1892, we find 731, and in 1893, 772 engines were constructed. Two rack-rail locomotives were built for a mountain road in Italy and twenty-five compound "Forney" locomotives for the South Side Elevated Railroad of Chicago. At the Columbian Exposition were exhibited seventeen locomotives, the product of the works, illustrating the various types of both "standard" and "narrow" gauge locomotives.

In 1892, a new design of high speed locomotive was produced by these works. This was the "Columbia" type, which had a two-wheeled leading truck, two pairs of driving wheels and a single pair of trailing wheels. A limited number of this type of engine was built for passenger service.

The depression in general business which set in in the summer of 1893 had a serious effect upon these works, and we find the number of engines completed in 1894 was 313. In 1895, a new type of passenger locomotive was brought out. To this the name "Atlantic" type was given. Its advantages are a large fire-box and boiler, enabling high speeds.

The first electric locomotive was built this year for the North

(Baldwin Locomotive Works.)

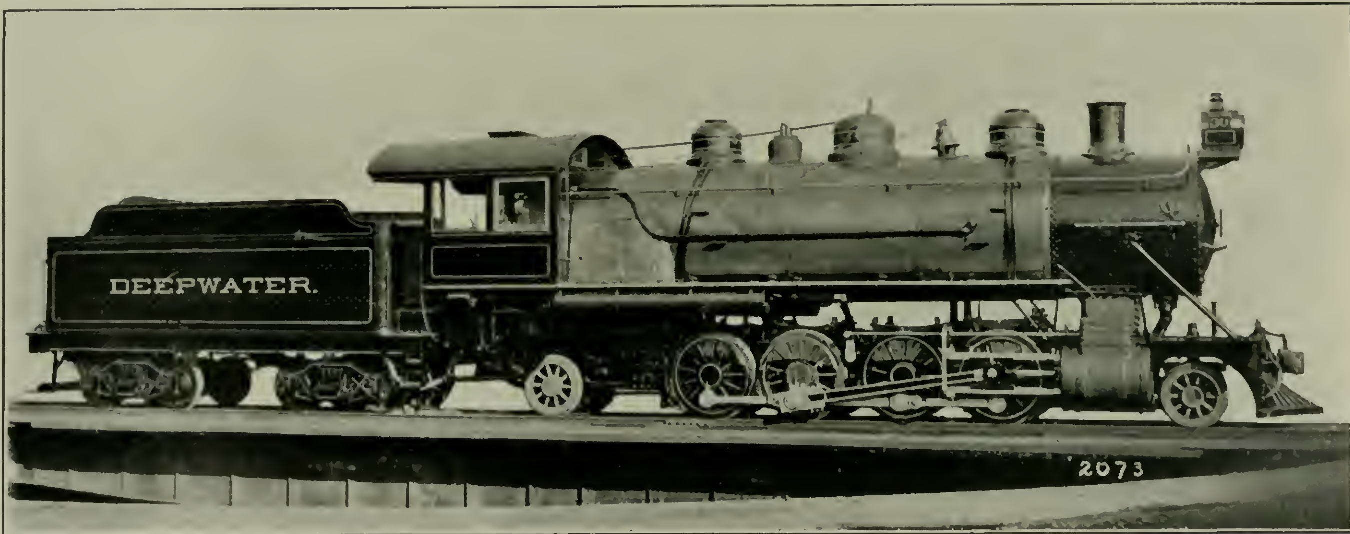

Fig. 8.—"Mikado Type."

American Company. Two other "Mine" electric locomotives were built in 1896 in cöoperation with the Westinghouse Electric and Manufacturing Company, they supplying the electrical parts.

A high-speed passenger locomotive was built for the Reading Railroad, having a single pair of drivers $84\frac{1}{4}$ inches in diameter. This engine and a duplicate built in 1896 were regularly used in hauling trains between Philadelphia and Jersey City, this distance being ninety miles. They accomplished this in 105 minutes, making six stops. A combination rack and adhesion locomotive was built for service in San Domingo. It was of the compound type, having the compound cylinders to operate two pairs of connected adhesion wheels and a pair of single expansion cylinders to operate a single rack-wheel, constructed upon the "Abt" system. This engine was furnished with two complete sets of machinery, entirely independent of each other, and was built eventually to remove the rack attachments and to operate by adhesion solely. During this year and in 1896, 138 locomotives of the four-cylinder compound type were sent to Russia.

In 1896, two combination rack and adhesion locomotives were sent to Mexico, having compound cylinders connected to the driving wheels through walking beams. Two pairs of wheels are secured to the axles by clutches and act as adhesion driving wheels and the rear wheels are loose on the axle and act only as carrying wheels. All three-coupled axles carry rack pinion of the "Abt" system.

Six ten-wheel locomotives were built for the Baltimore & Ohio Railroad for express passenger service, and have been operated with great efficiency.

In 1897, the Reading Railroad placed a fast express train in service between Camden and Atlantic City, N. J., $55\frac{1}{2}$ miles, allowing 52 minutes for the run, equivalent to a speed of sixty-four miles per hour. The railroad records show that for fifty-two days, July 2nd to August 31st, 1897, the average time consumed was but forty-eight minutes, or a speed of sixty-nine miles per hour and once the train covered the distance in $46\frac{1}{2}$ minutes or $71\frac{6}{10}$ miles per hour. These engines were of the "Atlantic" type, Vauclain Compound.

A new form of steam dome was patented and introduced in 1897. The dome base, or flange, was made of pressed steel, as was also the ring or top. The upper edge of the flange was in

(Baldwin Locomotive Works.)

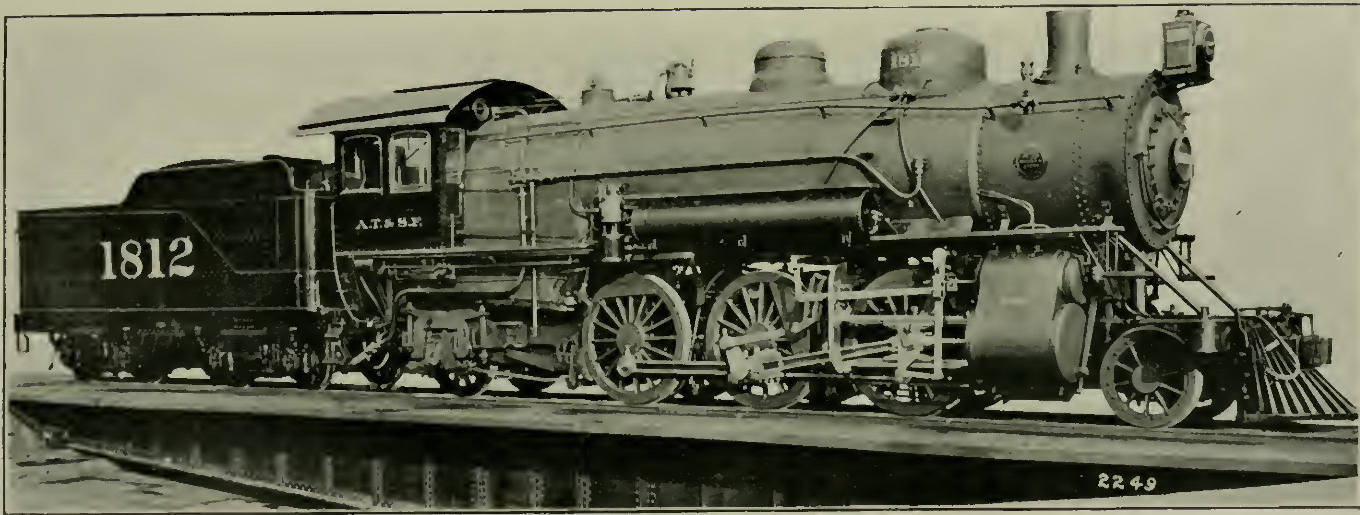

Fig. 9.—"Prairie Type."

one horizontal plane, so that the body, which was of boiler plate, was of uniform width throughout. The body was seamless, having a lap-welded joint. The interior of the flange was bored out to fit the body, which was shrunk over the ring, or top piece. The flange was radially planed to fit the boiler shell. This form of steam dome construction is universally used not only at the Baldwin Locomotive Works but in many other parts of the world. With the introduction of this form of steam dome, the practice was begun, at these works, of welding the longitudinal seam on the dome course. The seam was located on the top center line and was welded throughout its length on each side of the opening. This practice has become general on large boilers. A liner is frequently placed on the inside of the shell, to strengthen the joint.

In 1898, a "Consolidation" Vauclain Compound locomotive was placed in service upon the mountains between Coxton and Fairview, upon the Lehigh Valley Railroad. It was guaranteed to haul a load of 1000 net tons (exclusive of the weight of the engine and tender) upon a grade of sixty-six feet to the mile. It was so successful in the test that fourteen additional locomotives were subsequently ordered by this company.

In 1899, two "Atlantic" type Vauclain Compound locomotives were built for the Burlington Railroad, for fast mail service west of Chicago.

During this year there was a large increase in foreign business, including thirty locomotives for "Midland" and twenty for the "Great Northern" and twenty for "Great Central Railways of England," ten locomotives were ordered by the "French State" and ten by the Bone Guelma Railways, in the French Colonies of Algiers. Also, two Vauclain "Consolidation" freight locomotives for the Bavarian State Railways; and in 1900, this company ordered two passenger engines of the compound "Atlantic" type and embody in their passenger rolling stock the new features contained in these machines.

During 1900, these works exhibited at the Paris Exposition a "Goods" locomotive, "Mogul" type, for the Great Northern Railway of England; an "Atlantic" type pasenger locomotive for the French State Railways; also a compound "American" type passenger locomotive for this same road. These engines were built in the regular course of business for their respective companies

(Baldwin Locomotive Works.)

Fig. 10.—"Pacific Type."

and were put into service immediately after the close of the exhibition. The company filled large orders this year for the Chinese Eastern Railroad, the Paris-Orleans Railroad; the Finland State; the Egyptian State, and the Belgian State Railroads.

The incoming of the twentieth century witnessed an industrial "boom," and general prosperity throughout America, and in consequence entailed extraordinary demands for freight transportation. Cars were designed and built to carry heavier loads, resulting in improved road beds, heavier rails, stronger bridges, and more powerful locomotives. The demand for increased horsepower, involving greater steaming capacity and a larger grate area evolved the "Atlantic" type locomotive from the "American" type or eight-wheeled pasenger engine, so in order to produce a locomotive to cope with the enhanced condition, viz.: heavier trains at high speed. the "Prairie" type of engine was designed, a type resulting from the "Mogul" or ten-wheeled locomotive. This engine has a pony-truck, three pairs of driving wheels and a wide fire-box extending over the frames and placed back of the driving wheels. To support this overhanging weight a pair of trailing wheels is placed beneath the fire-box. Fifty of these locomotives were built for the "Burlington," and forty-five for the Atchison Railroads in 1901. A new departure in locomotive practice was exhibited by these works at the Pan-American Exhibition, at Buffalo, N. Y., in 1901, being a ten-wheel locomotive built for the Illinois Central Railroad, the fire-box and tender embodying the inventions of Mr. Cornelius Vanderbilt, M.E. The fire-box was cylindrical in form, its axis excentric to that of the boiler is riveted to the back head of the boiler and supported at the bottom by the man hole, otherwise entirely disconnected from the outer shell, and so dispensing with stays, bolts and crown bars, thus permitting easy removal.

The feature of the tender is a cylindrical instead of an U-Shaped tank, placed back of the coal space, the advantage being, a better distribution of the weight in the tender, less dead weight and more economical construction. The year 1901 was especially noticeable for the large volume of domestic business, there being a very large demand from the West and Southwestern Railroads; the Pennsylvania ordred over 150 locomotives of various types and the Baltimore & Ohio Railroad placed an order for over 100 locomotives. 1,375 locomotives were built, 526 being com-

(Baldwin Locomotive Works.)

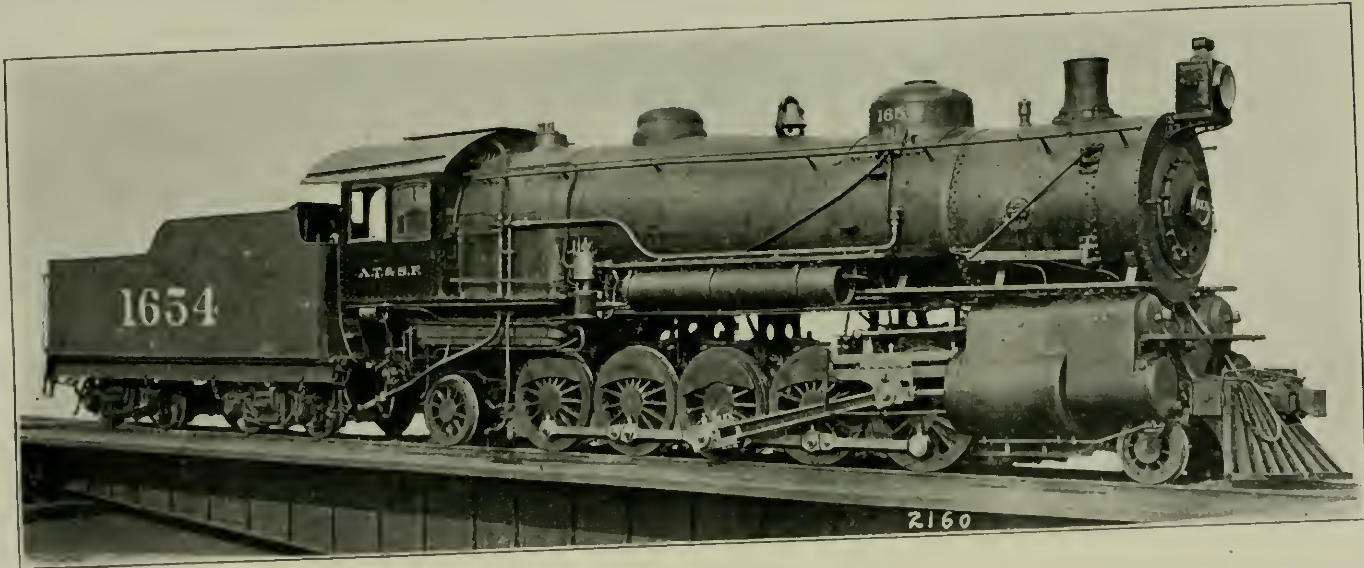

Fig. 11.—"Santa Fé Type."

pounds, six for compressed air and 45 electric. 208 were exported, and the average number of men employed per week was 9,595.

In February, 1902, the 20,000th locomotive was completed. This engine embodied several interesting features, viz.: compound cylinders, with the new arrangement, Vauclain type.

In May of this year, the largest locomotive ever built was turned out. It was a "Decapod," for the Atchison Railroad Company. The total weight of the engine alone was 267,800 lbs. It was designed for heavy hauling upon steep grades.

Two types of compound locomotives, the balanced and the tandem, both new in the practice of these works, were constructed in 1902. Both these types employ four cylinders. In the balanced engine they are placed side by side, with the two high-pressure cylinders between the frames, and the low-pressure outside. The high-pressure pistons are connected to a cranked axle. The inside and outside cranks on the same side of the engine are placed 180° apart so that the pistons oppose one another in movement and their disturbing effects are thus equalized. One piston valve controls the steam distribution to each pair of cylinders. The valve gear is arranged as in an ordinary single-expansion engine. This arrangement is particularly suitable for high speed pasesnger locomotives, as a more nearly perfect counter-balance can be effected. In the tandem type the high pressure cylinder is bolted to the front head of the low pressure with external bolts, which are easily accessible. The two pistons on the same side of the engine are mounted on a common piston rod. The packing between the two cylinders is so arranged that a steam-tight joint is maintained in spite of any wear which may occur in the various parts. The tandem arrangement of cylinders was one of the first to be employed on compound engines, but the Baldwin Locomotive Works introduced a number of valuable improvements. These features have been applied to more than 150 heavy freight locomotives built for the Atchison, Topeka & Santa Fé Railway.

The year 1902 also marks the introduction of the "Diamond" boiler seam, which has been used in a large number of locomotive boilers built at these works. The butt joint is covered on the outside by a narrow welt strip taking two rows of rivets, and on the inside by a diamond-shaped plate, which is secured to the shell by

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(Baldwin Locomotive Works.)

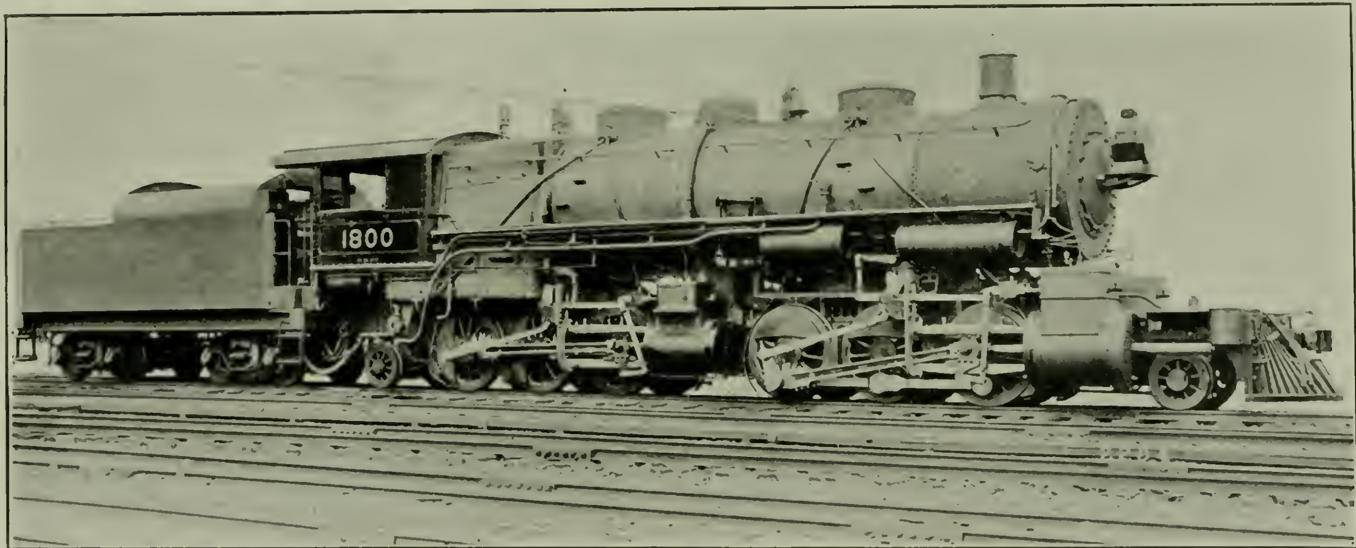


Fig. 12.—"Mallet Compound Type."

rivets placed in horizontal rows. The strength of this seam is estimated to be about 95% that of the solid plate. Another improvement relating to boiler seams adopted at these works about this time, consists in welding the boiler plate at each end of the horizontal seam where butt jointed seams are used. A stronger construction is thus obtained at the lap of the circumferencial seam and the scarfing or thinning down of the plates and covering strips at this junction is avoided. It also allows the sheets forming the two adjoining rings to be formed with a true radius, so that one will fit closely within the other for its entire circumference.

The "Mikado" type of locomotive was established this year. The requirements covered a powerful engine with a large fire box and ample grate surface for burning inferior coal or lignite. This type consisted of eight wheels connected, with the fire box behind them supported by a pair of trailing wheels, and a pony-truck in front.

Oil-burning locomotives were built this year for the "Atchison," the Southern Pacific and the Galveston, Houston & Henderson Railroads. Electric locomotives for surface and mine haulage showed a marked increase both in point of numbers and variety of design: also many orders for electric motor trucks were received.

In the year 1903, the "Santa Fé" type of locomotive was introduced for heavy freight service upon the Atchison, Topeka & Santa Fé Railway. These engines have five pairs of drivers connected, with a two-wheeled truck at each end. 150 of these locomotives are operating on this railway system, while others are being built.

78	locomotives	were	exported.
298	"	"	compounds.
1646	"	"	other types.
2022	"	"	constructed during the year

The years 1904 and &1905 witnessed no new developments, yet general improvements progressed and we find the number of locomotives constructed during these years to be:

Fig. 13—"Riggenbach" System

	Exported.	Compounds,	Total.
1904	285	99	1453
1905	413	123	2245

Of the number of men employed:

In 1904 there were 10,573.
" 1905 " " 14,811.

In 1906, five locomotives of the "Mallet" type were built for the Great Northern Railway Company. A new feature in these locomotives, introduced by these works, was the addition of a two-wheeled radial truck at each end of the engine. This results in better curving qualities and reduces the flange wear on the leading pair of driving wheels. These engines are the heaviest thus far constructed in the experience of the works. The total weight of the locomotive is 355,000 pounds. The weight upon the drivers is 316,000 pounds. The weight of the engine and tender is 503,000 pounds. These locomotives are doing very excellent service upon the roads where they are employed. Forty additional ones have already been ordered owing to their good service.

Locomotives exported in 1906..................281
" compounds in 1906...............133
Total number in 1906.....................2652
Number of men employed in 1906............17,432

In compiling their report, the Committee have been obliged to give but a brief outline of the growth of these works; to overlook many interesting and valuable details of construction and patents, confining themselves to the fundamental patents and details which were essential to the successful development of their locomotives; and would recommend for originality, invention, design, workmanship, system and management, the award of the Elliott Cresson Medal and Diploma of the Franklin Institute, of Pennsylvania.

Journal Franklin Institute, vol. clxiv, October, 1907.

(Baldwin Locomotive Works.)

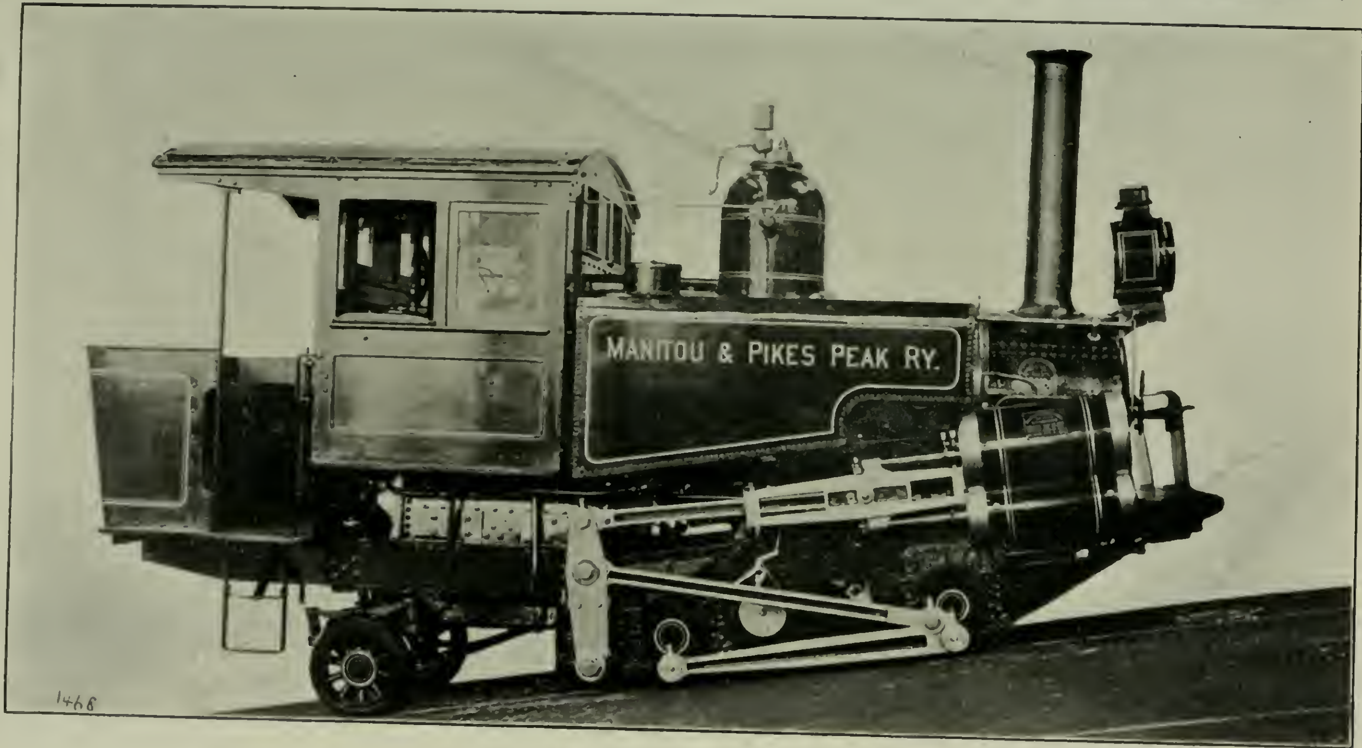


Fig. 11.—"Abt" System—Rack Rail.

APPENDIX.

RECAPITULATION.

Year.	Number of Engines Built.	Compound Locomotives.	Locomotives Exported.	No. of Men Employed.
1832	1			30
1833	0			
1834	5			
1835	14			
1836	40			
1837	40			300
1838	23			
1839	26			
1840	9		1	
1841	9		2	
1842	14		0	
1843	12		0	
1844	22		0	
1845	27		3	
1846	42		2	
1847	39		2	
1848	20		1	
1849	30		3	
1850	37		3	
1851	50		5	
1852	49		0	
1853	60		4	
1854	62		1	500
1855	47		5	430
1856	59		4	
1857	66		12	
1858	33		5	
1859	70		10	
1860	83		3	
1861	40		2	
1862	75		6	
1863	96		9	
1864	130		4	
1865	115		0	
1866	118		5	
1867	127		4	
1868	124		4	
1869	235		10	
1870	280		12	
1871	331		18	
1872	422		52	
1873	437		85	
1874	162		47	

(Baldwin Locomotive Works.)

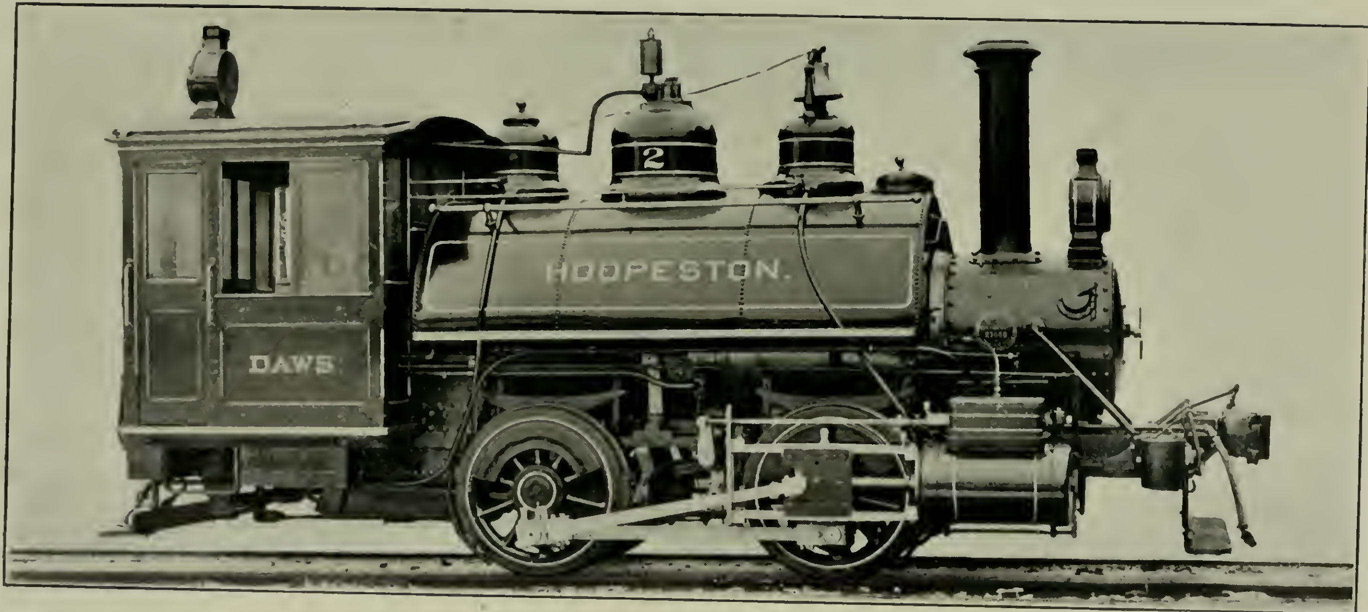


Fig. 15.—"Four-Coupled Switch."

Journal Franklin Institute, vol. clxiv, October, 1907.

(Baldwin Locomotive Works.)

Fig. 16.—"Four-Coupled Switch."

Year.	Number of Engines Built.	Compound Locomotives.	Locomotives Exported.	No. of Men Employed
1875	130		30	
1876	232		47	
1877	185		37	
1878	292		79	
1879	308		90	
1880	577		53	
1881	554		89	
1882	563		119	
1883	557		151	
1884	429		170	2377
1885	242		82	1563
1886	550		42	2411
1887	653		46	2879
1888	737		93	3329
1889	827	1	211	3579
1890	946	3	144	4493
1891	899	82	290	4440
1892	731	213	127	4039
1893	772	160	162	4313
1894	313	30	132	2150
1895	401	51	151	2551
1896	547	173	289	3490
1897	501	86	205	3191
1898	755	235	348	4888
1899	901	241	375	6336
1900	1217	426	363	8208
1901	1375	526	208	9595
1902	1533	445	100	12158
1903	2022	298	78	14720
1904	1453	99	285	10573
1905	2245	123	413	14811
1906	2652	133	281	17432

Total number of engines exported up to January 1, 1907..............5614

Total number of engines (compound) up to January 1, 1907............3325

(Baldwin Locomotive Works.)

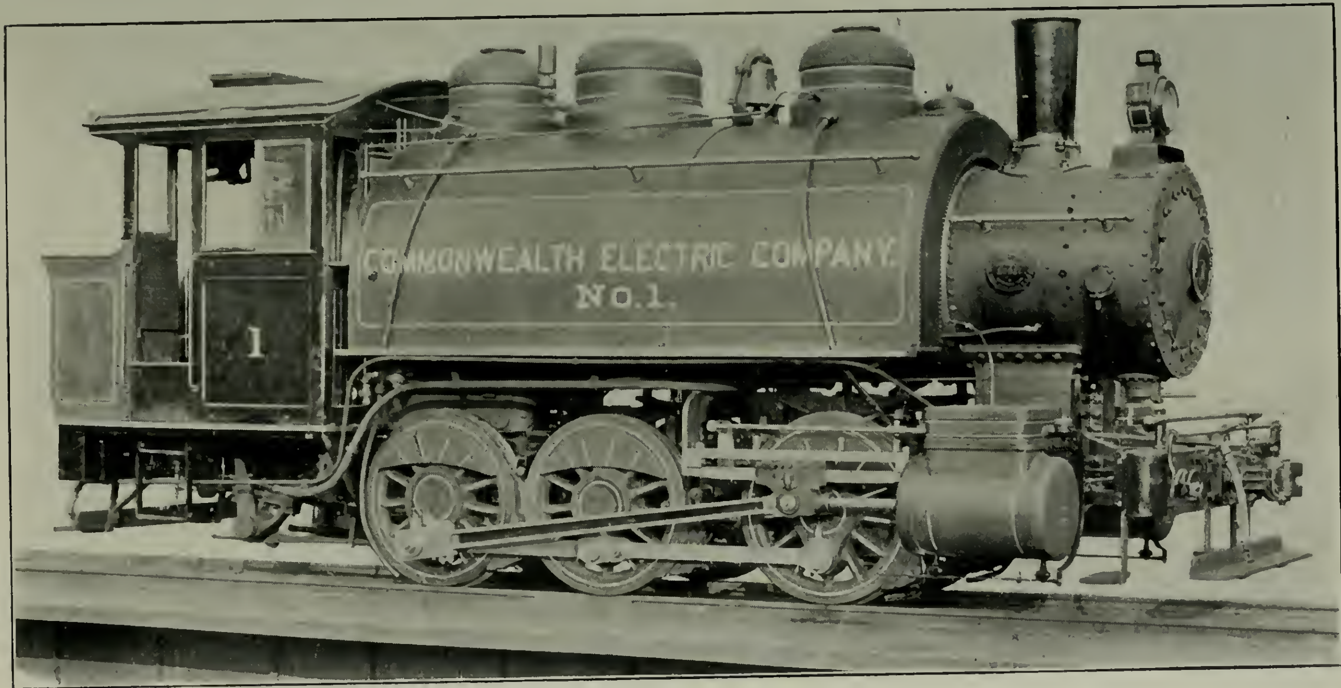


Fig. 17.—"Five-Coupled Switch."

(Baldwin Locomotive Works.)

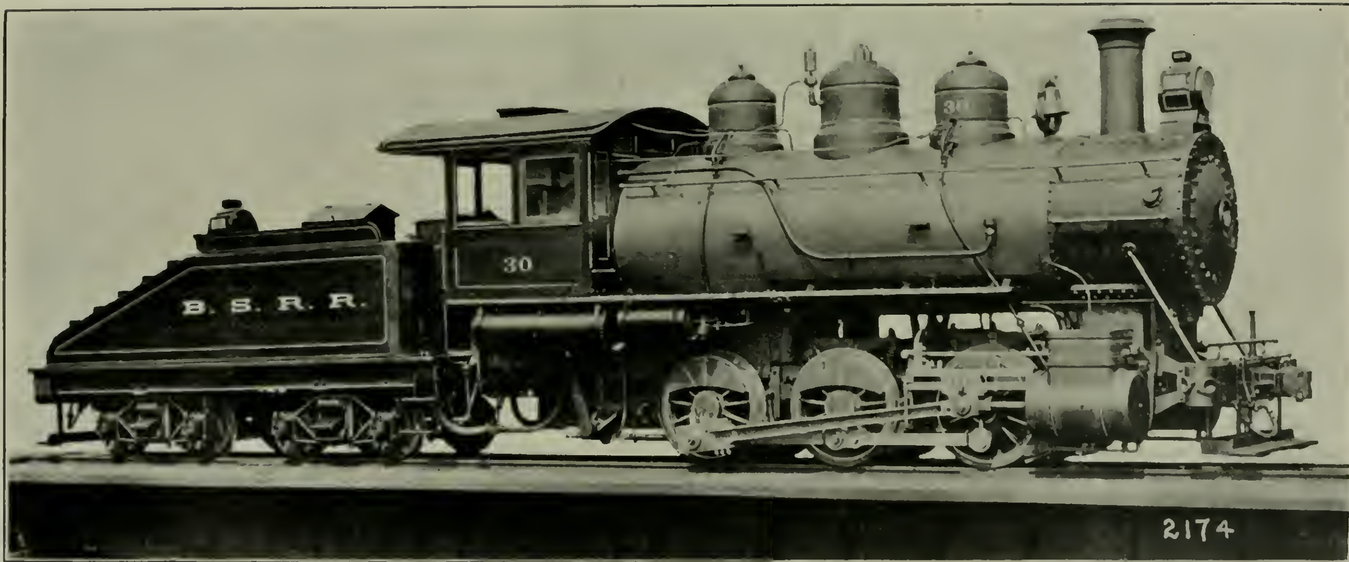


Fig. 18.—"Six-Coupled Switch."

The present organization to date, based on an annual output of 2600 locomotives, is as follows:

Number of men employed		19000
Hours of labor per man per day		10
Principal departments, run continuously, hours per day		23
Horse power employed	Steam engines	12138
	Oil engines	4850
Number of buildings comprised in the Works		47
Acreage comprised in works	Philadelphia	17.8
	Eddystone	184.0
Acreage of floor space comprised in buildings		63.2
Number of dynamos for furnishing light (arc)		16
Number of dynamos for furnishing light (incandescent)		7
Horse power of electric motors employed for power transmission aggregate		14200
Number of electric lamps in service (incandescent)		7000
Number of electric lamps in service (arc)		951
Number of electric motors in service		1115
Consumption of coal, in net tons per week, about		3000
Consumption of iron, in net tons per week, about		5000
Consumption of other materials, in net tons per week, about		1460

Adopted at the stated meeting of the Committee on Science and the Arts, held Wednesday, April 3, 1907.

Attest:

WM. H. WAHL, *Secretary.*

(*Stated meeting held Wednesday, March 20, 1907.*)

The Secondary Current of the Induction Coil.

By H. Clyde Snook, A.M.

The purpose of this paper is to give a discussion of the currents flowing in the secondary of an Induction Coil, as observed by means of a Duddell High Frequency Oscillograph.

The principal apparatus used in this investigation consisted of a Duddell High Frequency Oscillograph and a twenty-inch Ruhmkorff Induction Coil, equipped with an electrolytic interrupter, a mercury jet interrupter, and a mechanically vibrating platinum contact break. A general view of the apparatus appears in Figure 1.

The Oscillograph is provided with a falling plate apparatus in the usual manner. The arc lamp which furnished the light for the moving beam that traced the curves is in the foreground near the falling plate arrangement. The mercury jet interrupter, a lead glass shield enclosing an X-Ray tube, and a milliampere meter for measuring the secondary current are in the left foreground.

Curves No. 12 to No. 20, inclusive, are of the current at the middle of the Induction Coil secondary, and were taken by inserting the oscillograph loop directly in series with the two halves of the secondary. The method of connecting up the apparatus was such that the only difference of potential between the oscillograph parts was due to the I. R. drop through the resistance of the oscillograph loop.

This was effected by connecting the permanent magnet of the oscillograph to one side of the loop and making a ground connection to earth at this point. It is true that the loop has a very slight self-induction and that there would be a very slight $L\frac{di}{dt}$ drop through it, and this would be added to the I. R. drop, but their sum is very small, so that the entire oscillograph is subjected

to very low differences of potential. By making the middle of the secondary a neutral point at zero potential, the induction coil secondary was permitted to develop its usual high potentials without endangering the recording apparatus.

No. 12 is of the current at the middle of the secondary, obtained in the manner just indicated, when there is no sparking at the terminals of the secondary coil. It is seen that current is

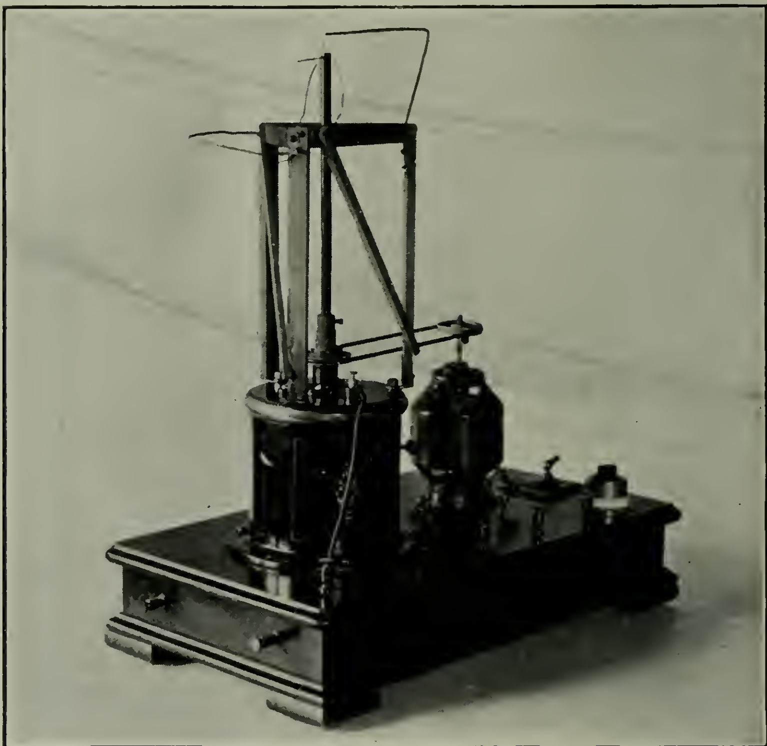


Fig. 1

flowing at the middle of the secondary winding even though no current is passing at the terminals. This is evidently due to the fact that the secondary is oscillating through its own self-induction and electro static capacity as an open-circuited Hertz resonator, the natural period of the thus self-constituted resonator being indicated by the shorter waves in each of the wave trains.

In this curve, as in a number of others, the zero line has been

shifted away from the true zero in order that the minute wave forms may be more clearly distinguished.

Curve No. 13 was taken under the same conditions as No. 12, with the exception that a bright snappy sparking was occurring at the secondary terminals of the induction coil. The effect of the sparking is seen in the extra tiny wiggles and the slight change in the contour of the larger waves, which latter effect is due to a change in the leakage inductance between the secondary and primary coils of the induction coil. One of the wave trains in this curve is seen not to have the tiny wiggles which are due to

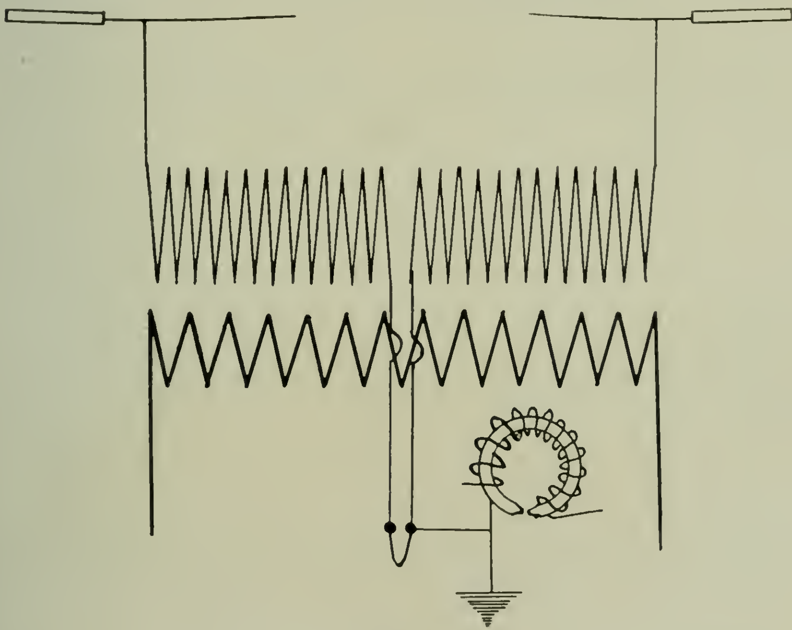
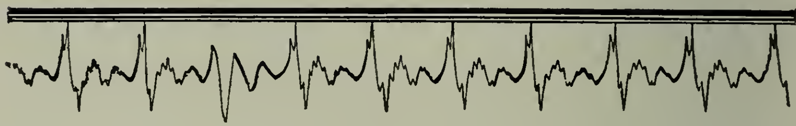


Fig. 2

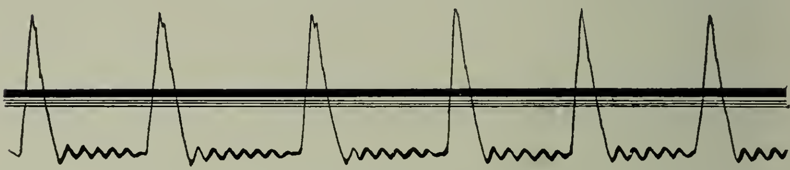
the spark and its very high frequency oscillation which penetrates entirely through the secondary winding, but which has a still higher frequency than that of the natural period of the secondary winding when oscillating entire as an open-circuited resonator. On one of the wave trains it is seen that the spark failed to occur, and that the shape of the waves in this train is just the same as that in curve 12, where sparking did not occur.

The previous curves, as well as this one, were obtained when the electrolytic interrupter was being used in the primary circuit

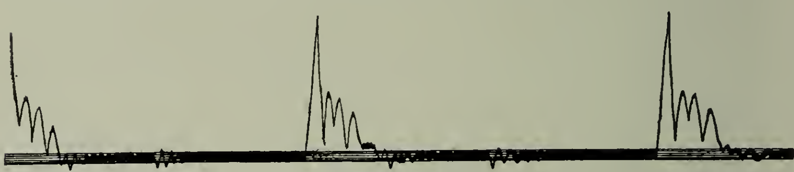
CURVE NO. 12.



CURVE NO. 13.

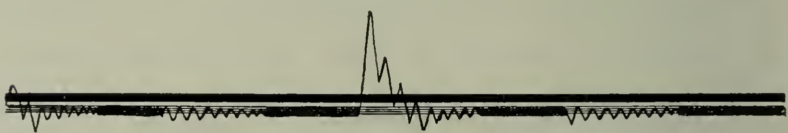


CURVE NO. 14.

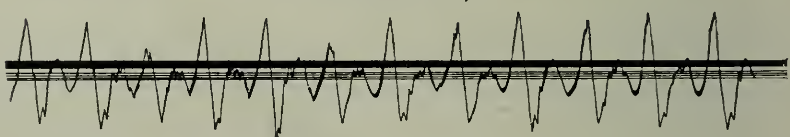


CURVE NO. 15.

CURVE NO. 16.



CURVE NO. 17.



CURVE NO. 18.

of the coil. This curve was obtained by permitting the secondary terminals to be only a few inches apart, and causing a heavy yellow flaming discharge to pass between them. The high wave peaks correspond to the "breaks" of the interrupter, and the tiny wavelets are again the oscillations of the same secondary but their time period is less than in curve No. 12 because in this instance the time period has been reduced by the lessening of the effective capacity of the ends of the secondary winding due to the low resistance of the flaming discharge.

When bright heavy sparking takes place at the secondary terminals, and the primary coil is operated by a platinum hammer break which is bridged with a moderate amount of condenser, we obtain a curve like No. 15. The self induction in the primary winding, when this curve was taken, was of medium value, and it, oscillating with the condenser bridged around the interrupter, caused the serrations in the main wave which occurs at "break." The regular and steady oscillations of the secondary are seen in a low wave train immediately preceding the large wave occurring at break.

No. 16 is quite similar to No. 15, but the electrolytic interrupter was employed. The saw teeth following the large wave occurring at "break" indicate very nicely the prolonged oscillation of the secondary. In this curve four milliamperes of current were being passed through an X-Ray tube having a parallel resistance of about two inches.

No. 17 is identical with No. 15, all adjustments being exactly the same excepting that the discharge was passed through a harder X-Ray tube, and it is seen that the current does not rise to so high an instantaneous value because of the increased tube resistance. The condenser oscillations are seen to serrate the wave form of the current at break, and when the latter has fallen to a low enough value they produce current of a negative sign.

By employing a low value of self induction in the primary coil, a high frequency of interruption by an electrolytic interrupter, and a soft X-Ray tube in series with the secondary, the current curve at the middle of the secondary is as in No. 18. The soft tube offers a low resistance to current of both positive and negative sign and a great deal of inverse current or current of negative value is seen in this curve.

Remembering that this curve is of current at the middle of the

secondary winding, we find a most interesting thing due to the superimposition of the high frequency secondary oscillations upon the low frequency oscillations of the primary condenser and self induction which assert themselves in the secondary through the mutual induction between the primary and secondary windings. This is seen immediately following the large positive waves which occur at break. Midway between the large waves at break can be seen the oscillations of the secondary occurring at "make" while the secondary oscillates as an open-circuited resonator, being maintained open circuited in this particular time by the high resistance of the X-Ray tube, which at this instant does not permit the passage of any current through it from the secondary winding. The conditions in the primary when this curve was taken were, a large primary self induction, a mechanical platinum interrupter shunted by a large mica condenser, and a period of interruption of about twenty-five cycles per second; while the secondary had in series with it a soft X-Ray tube, and a small spark gap.

No. 20 was taken under exactly the same conditions as was No. 19 excepting that the electrolytic interrupter was used in the primary. The wave form is profoundly altered and is characteristic of the wave forms produced with this type of interrupter.

We now proceed to examine the current not at the middle of the secondary winding but at one end of it, in order that we may obtain a true record of the current which actually passes through the X-Ray tube and thus eliminate the oscillatory current which occurs only in the secondary winding, and which moves under the stimulus of comparatively small electro-motive forces. It will be seen in the subsequent curves that in the majority of cases these secondary oscillations never pass through the X-Ray tube because their maximum potentials are insufficient to equal the ionization potentials of the X-Ray tubes.

This diagram indicates how the oscillograph was maintained at a zero potential as in the previous curves, but instead of having the current connection at the middle of the secondary it is placed at one end of it. The electrode of the tube which is connected to the oscillograph has of course a low resistance connection to it, and there is maintained at practically zero potential, one end of the secondary winding, the oscillograph, and one of the electrodes of the X-Ray tube.

In this connection it is interesting to note that some of these

succeeding curves are taken with the Kathode of the X-Ray tube maintained at zero potential, and some of them with the target maintained at zero potential. This was done in order to determine whether or not it is necessary to raise a kathode to a high *absolute* potential in order to cause it to emit kathode rays. It was found that the X-Ray tube behaved exactly the same in each case, no matter which way about the electrodes were placed with reference to the zero point, and the charactristics of the tube as to

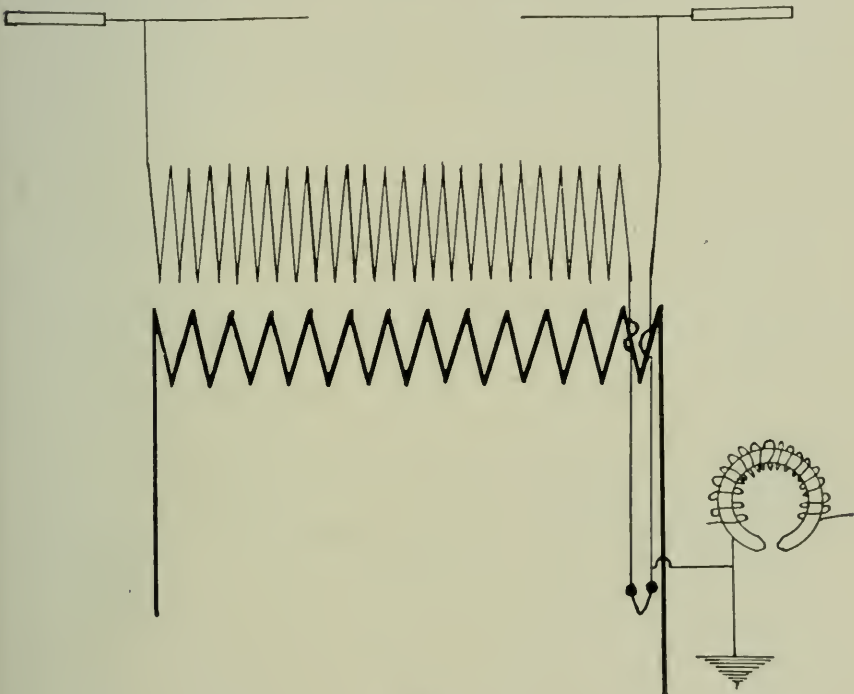
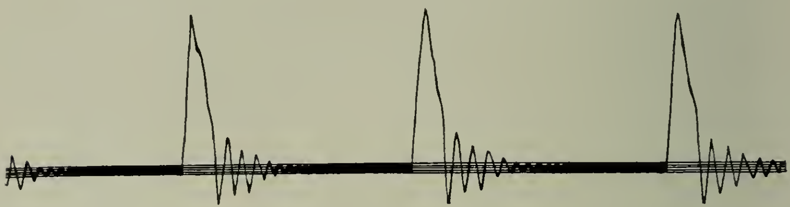


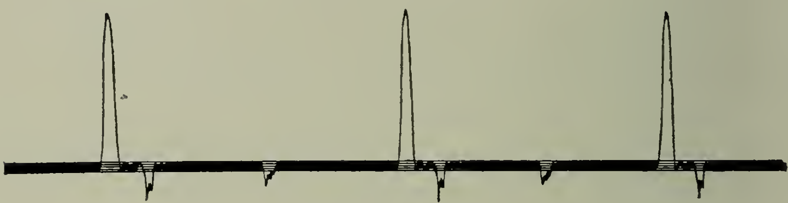
Fig. 3

resistance and emission of X-Rays remained absolutely the same in either position. It was therefore concluded that since no change in the tube characteristics was observed by making the kathode be at zero potential from the behavior of the tube when the kathode was made the high potential electrode, that the production of the kathode rays can take place at the surface of a kathode maintained at zero potential but between which and any other electrode in a Crooke's tube a sufficient difference of potential is maintained.

CURVE NO. 19.

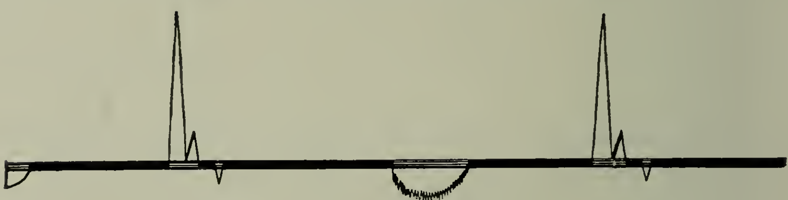


CURVE NO. 20.

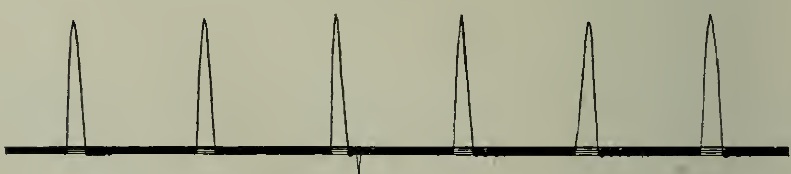


CURVE NO. 21.

CURVE NO. 22.



CURVE NO. 23.



CURVE NO. 24.

In this curve No. 21 we have the curve of current which actually passes through the X-Ray tube. It is seen that the maximum instantaneous value of the current is at times quite high but that the current lasts for very short intervals of time. If we take as land marks the tall peaks of positive current which comes at "break," we notice the negative current at "make," midway between these tall waves at "break." Immediately following the tall waves we see a negative wave of very short duration which is caused by the first semi-oscillation of the primary condenser which produced negative E. M. F. in the secondary, and it is to be noted that the succeeding condenser oscillations fail to produce sufficient potential to equal the ionization potential of the tube. The abruptness with which the current in the tube begins and ends at this semi-oscillation of the condenser, in spite of the fact that the current through the primary due to the condenser oscillation is a damped sine wave, proves the existence of a definite ionization potential for the tube. The oscillation due to the capacity of the tube electrodes, the wires leading to it and the secondary coil, are seen in small wavelets between the tall peaks of positive current and the negative wave caused by the primary condenser.

In No. 22 we have all the conditions the same as in No. 21, but the condenser and primary inductance have been adjusted so as to prevent the production of negative secondary potential of sufficiently high value to equal the negative ionization potential of the X-Ray tube. The curve is entirely above the line, which is as it should be, and is often exceedingly difficult to obtain.

If the X-Ray tube be very soft, its negative ionization potential is correspondingly low, and the negative voltage produced at "make" easily passes current through the tube in the wrong direction. In curve No. 23 midway between the tall peaks of current at the time of "break" we find a wave of current at "make" which lasts for a comparatively great length of time. In this curve can be seen a peak of positive and negative value due to the primary condenser oscillations. Serrating the negative curve at "make" can be seen the high frequency oscillations of the induction coil secondary.

This curve No. 24 is of current in an X-Ray tube when the current is passed through the tube in the proper direction, and there is none in the wrong direction. In this particular curve the in-

duction coil was excited by an electrolytic interrupter, the adjustment of which together with the adjustment of the number of turns on the primary and the rheostat in series with both and the source of current was such as to prevent the negative voltage from equaling the negative ionization potential of the tube.

We have here a mercury jet interrupter directly connected to the shaft of which is a hard rubber rod which has mounted at its upper end a metal rod which rotates around with it. This metal

Fig. 4

arm or rod in its rotation bears a definite phase relation to the "make" and "break" of the interrupter, and is so arranged that when the interrupter is at "break" this metal arm closes the secondary circuit of the induction coil through a very small air gap. When, however, the mercury interrupter is at "make" this rotating arm is at such a position that it has introduced into the secondary circuit a large spark gap, which is so great that the negative voltage produced in the secondary winding by the "make" of the interrupter will not bridge across this gap. This constitutes a synchronous series spark gap maintained in series with the sec-

ondary winding of the induction coil in such a way that it has a minimum resistance at the time of "break" and a maximum resistance at the time of "make," thus enabling us to prevent the passage into the external secondary circuit any current induced in the secondary at the time of "make." The speaker has used this apparatus in the manner indicated, and has taken oscillographic records of the curves obtained by it, and as would be expected they are the same as previously obtained without the use of such a synchronous series spark gap, excepting that there is not present in the curves any indication of current in the external secondary circuit at the time of "make."

This investigation of the currents flowing in the secondary of this particular induction coil was a part of a general investigation of various kinds of induction coils which was undertaken by the speaker under Dr. Arthur W. Goodspeed, Professor of Physics at the Randal Morgan Laboratory of the University of Pennsylvania. The speaker is greatly indebted to Dr. Goodspeed for his encouragement and his placing the use of the oscillograph and other apparatus at the speaker's disposal.

STRAWBOARD WASTE.

A recent publication of the United States Geological Survey that should have wide circulation in the States where strawboard is manufactured is a paper entitled "The Prevention of Stream Pollution by Strawboard Waste." The author is Mr. Earle Bernard Phelps.

The total waste discharged into the streams in 1900 amounted to 10,239,710,000 gallons of liquor, containing 184,777,382 pounds of straw and mineral matter and 77,191,660 pounds of lime. This enormous waste was discharged by fifty-nine plants or various sizes, but as most of these mills are along small streams the resulting pollution is very apparent.

Experiments conducted in the Sanitary Research Laboratory and Sewage Experiment Station of the Massachusetts Institute of Technology show that 93 per cent. of the suspended organic solids and 98 per cent. of the total suspended matter determined as turbidity can be removed, after a short period of sedimentation, by filtration of the liquor through sand, without coagulants. The present method, that of sedimentation in large fields, is pronounced unsatisfactory, expensive, and based on a wrong principle. The sludge resulting from the sedimentation tanks is declared inocuous after being pressed. It is said to make good soil and to have some value as a fertilizer.

UNDERGROUND WATERS OF THE COASTAL PLAIN OF TEXAS.

The underground waters of the Texas Coastal Plain, which during recent years have become of considerable economic importance, form the subject of a paper just issued by the United States Geological Survey as Water Supply Paper No. 190. The author is Prof. Thomas U. Taylor, of the University of Texas, who has spent a number of years investigating ground water conditions in that State.

The Coastal Plain of Texas is a continuation of the Atlantic Coastal Plain, although it differs from that area in many important features. It consists in general of a gently sloping plain, about 150 miles wide, lying between the Gulf coast and a line connecting Texarkana with Del Rio and running through Cooper, Greenville, Corsicana, Cameron, Elgin, and San Antonio. On the west, from Del Rio to the Colorado River, it is bordered by what is known as the "Edwards Plateau," and from Colorado River to the Arkansas State line by the "Black Prairie." Its area is about 75,000 square miles.

In eastern Texas the Coastal Plain has the general character of that of the Southern States; but in its southwestern extension that character is more or less modified, and it widens in the vicinity of Rio Grande, where there is a great embayment similar to that of the Mississippi. The surface rises gradually from sea level to an elevation of 800 to 1000 feet along the inner margin of the province. The region is traversed by many rivers, the largest being Neches, Trinity, Brazos, Nueces, and the Colorado. Of these only the Brazos enters the Gulf directly, all the others emptying into lagoons or bays. Notwithstanding its many streams much of the region is poorly drained, and in places water stands in lakes or ponds throughout the year.

Ground water, which is usually abundant throughout the district, has been used there for many years for general domestic purposes, and a few small irrigation plants have derived their water supply from this source. Within recent years artesian wells have been obtained in various parts of the region, the depth at which the water is found ranging from a few feet to over 2000 feet, with the average of about 600. Three of the largest cities in the region derive their entire city water supply from artesian sources. The flow of the wells varies from 20 to 16000 gallons per minute.

Professor Taylor's report discusses the water resources of this important district by counties and gives all available information, collected from many sources, concerning both shallow and deep wells. The many chemical analyses included indicate that, while the water of the Coastal Plain wells is more or less mineralized, the dissolved salts are as a rule neither objectionable for domestic purposes nor deleterious to plant growth. The report may be obtained by applying to the Director of the United States Geological Survey, Washington, D. C.

Section of Physics and Chemistry.*

On Shellac and a Method for the Determining of Its Impurities or Adulterants.

BY H. ENDEMANN.

Shellac has frequently been the subject of investigation. It is generally conceded that it consists mainly of oxy acids, wax, coloring, inorganic matter, etc.

A. Farner, Chem. Cent. Bl., 1899, p. 687, separated from the oxy acids one crystalline product which he called Aleuretic acid, which, as he judges, should yield when treated with permanganate of potash in alkaline solution azelaic acid and butyric acid. I may state here that I have also obtained a crystalline acid similar to that described by Farner, which, however, is not aleuretic acid, but rather a trioxy palmitic acid, of which more anon.

I will now describe the results of my own investigations, so far as they refer to my method of analyzing shellac in order to determine its qualities and purity.

In investigating shellac one should commence with the best and purest shellac of commerce. I chose the mark "D. C."

If such shellac is treated with a caustic alkali, it leaves an insoluble residue, the so-called "wax." In order to purify this I extracted it with boiling alcohol in a Sohxlet apparatus and purified the crystals so obtained by recrystallization from ether.

Analysis yielded:

	Sample	Calculated for Myricyl-alcohol.
Carbon	82.18	82.08
Hydrogen	14.25	14.27

but no Cerylalcohol which requires C. 81.82, H. 14.16.

Manufacturers obtain the wax as the insoluble residue after dissolving shellac in a carbonate of soda solution.

[*Submitted for publication and approved. ED.]

The carbonate of soda solution precipitated by an acid yields the main portion of the shellac apparently intact.

If the shellac, while in this alkaline solution, is bleached with hypochlorite of soda (as is done on the large scale) and subsequently precipitated with acid, the shellac is not obtained unchanged but containing chlorine. An analysis of bleached shellac showed in one case as much as 1.26% of chlorine. It would involve, therefore, considerable complications if bleached shellac were employed for an investigation of shellac constituents, though almost colorless products are at once obtained.

For the purpose of an investigation it is, therefore, far more desirable to select one of the "so-called" blond shellacs. Mark "D. C." has been used by me as a standard.

Shellac boiled with water yields a white crystalline acid (rhombic plates) to which we will refer later.

A solution of shellac in carbonate of soda boiled for one (1) hour connected with a carbonic acid absorption apparatus does not yield as much carbonic acid as would be expected from the quantity of acids contained in shellac.

2.5146 grams shellac with 1.0083 dry carbonate of soda and water were boiled and yielded 0.074 carbondioxide, while from later data 0.181 should have been expected, if the acids were really available, *i. e.,* in a free state. The stability of about two-thirds of the mass seems decidedly in favor of the assumption that these bodies are present as anhydrides.

That shellac is soluble in carbonate of soda solution has given rise to the assumption that it is a free acid. If it were, the whole of the calculated CO_2 should have been given up. In fact shellac acts precisely the same as many other oxy compounds, which show acid properties even in the absence of available carbonyl groups.

Hydration of shellac by means of caustic soda or potash produces Benedicts' liquid shellac, which leaves the myricyl alcohol behind. There is also another body set free, though only in minute quantity. When the distillation from which the myricyl alcohol has been eliminated is performed in a still it passes over with the water vapors. It possesses the odor of geraniol, but later on crystallizes. Working on a rather large scale I obtained from 100 shellac "D. C."—

4.5% Myricyl alcohol.

8.0% Acids (apparently not oxy acids, and not condensable by acids, and other impurities.)

87.5% { 27.0% of a water soluble acid (oxyacid crystallizable). 60.5% of an oily oxy acid, but slightly soluble in water, besides coloring matter and other impurities. Hydration is established when we consider that 100 parts of shellac yields 104.5 parts products.

Dehydration may be reached in two ways. If shellac is kept liquid above its melting point for a considerable period of time it becomes gradually thicker and finally reaches a point when it becomes a gelatinous mass, which on cooling resembles rubber. This process is accompanied with a loss of weight.

This process can be much accelerated when we treat shellac with a concentrated mineral acid, like hydrochloric acid. It thickens at first, then, while moist, becomes like India rubber. The greater portion is insoluble in alcohol and always contains the wax and chlorine and for this reason is hardly useful for quantitative determinations in analytical work. Alcohol extracts from this about 8% of organic acid and inorganic salts, etc., not condensed or dehydrated by this treatment.

If liquid shellac is extracted with water, about 15% of a soluble crystallizable acid is easily removed. The rest, or about 12% more, is better removed by redissolving the residue in alkali and re-precipitating with acid from very dilute solution. It is then recovered from the aqueous solution after concentration and cooling.

Some of the insoluble, or rather very difficultly soluble, oily non-crystallizable acids, however, go into solution. In order to separate the latter, concentrate the solution somewhat until some of the acid will crystallize on cooling. This will carry the oily acid with it. The filtrate, on further concentration, will leave the crystallizable acid in a far higher state of purity.

Repeat this several times, using always the mother liquors for the purer product. The acid finally obtained by this manipulation is a pure white, very light, powder, which under the microscope appears in the form of rhombic plates or leaflets. One part dissolves in about 40 parts of water at the ordinary temperature. Oxidation with permanganate produced a very difficultly soluble acid which yields in the average

C.	57·33
H.	9.03

Hence resembling azelaic acid.

This crystallizable acid from shellac melts, when air dry, at 97.5° C.; and when dried under air pump, at 98.3° C.

Melted at 102° C. and tested next day melts at 89° to 94.5° C. (anhydride formed in part.)

On combustion this crystallizable acid yields, dessicator dry:

			Calculated for $C_{16}H_{32}O_5$.
C.	63.15		63.096
H.	10.53		10.614
Equivalent by titration	304	very sharp.	
In another preparation dried by heat,	301		304.3

This acid $C_{16}H_{32}O_5$ has, therefore, a composition corresponding to trioxypalmitic acid. Evaporated with hydrochloric acid the crystals do not reappear; either an anhydride or a lactone being formed. Chlorine also is present.

For instance, the crystallizable oxy acid when dehydrated by hydrochloric acid loses in weight 2.79% but it also contains 6.3% chlorine, very likely introduced into the acid by the reaction of the hydrochloric acid with one or more of the hydroxyl groups contained therein. The oily oxy acids behave the same; they lose in weight by heat and either substitute chlorine or add H. Cl. for the reason that they are unsaturated compounds.

Other rosins examined, and especially pine rosin, remain perfectly unchanged by the hydrochloric acid treatment.

Aleuretic acid $C_{13}H_{26}O_4$ was not met with, for its equivalent would be 246, according to Farner, but its composition of C. and H. yields figures very nearly those found by me, namely, C 63.4 H 10.6, and it melts at 101.5° C. The acid $C_{16}H_{32}O_5$ crystallizes well even in the presence of the liquid acid, and the melting point would be enhanced by some of this liquid acid being present, for the reason that in drying, preliminary to the determination of the melting point, a high temperature might be employed which would produce lactones of the liquid acid which do not melt readily. I dry either below 100 or by means of H_2SO_4 under the air pump.

It has been suggested that it was important to determine the actual constitution of this trioxypalmitic acid. I do not consider this necessary for a paper of this kind. However, the formation of azelaic acid would suggest the presence and position of one

hydroxyl group. It is certain only that the theory of Farner, that butyric acid would be formed while convenient to his aleuretic acid formula, could not be verified. 4.5 grms of trioxypalmitic acid treated in strongly alkaline solution with permanganate of potash, yielded after acidification a steam distillate practically free from volatile acid, requiring 0.032 NaOH for neutralization, and no odor of butyric acid. About 0.067 grms of an indifferent body could be extracted from the peroxide of manganese, and both are very likely but by-products of the reaction.

A great difficulty with these oxyacids exists in the ease with which they form anhydrides and lactones as is shown by the change in melting point and acidity, when they are subjected to high temperatures above 90° C. If the water thus lost were water of crystallization the acidity of the remaining bodies should be enhanced. but instead of this the acidity is lowered.

The liquid acid, or rather acids, have not been studied by try ing to isolate special compounds. As obtained they are mixtures of condensable as well as non-condensable acids, *i. e.*, such as are converted into lactones and anhydrides and such as are not. While under water, these acids are liquid, but when dried under the air pump, or at 85° to 90° C., they become quite thick and will no longer flow, resembling a very concentrated solution of gum arabic. Dried first under the air pump they still lose about 1.25% water when dried at 85° to 95° C. for twenty-four hours. On combustion they then yielded

	Dried by heat below 98°C.	Dried under air pump only.
C.	65.76	64.94
H.	9.71	9.72

Equivalent by titration 288 (287.9) in water and alcohol mixed solution for sample dried under air pump only.

There is in this nothing to show but that, considering the ratio of C to H in this mixture it is evident that there is less H than in the crystallizable acid, leading to the conclusion that these acids are rather oleic oxy derivatives or such as are derived from other derivatives of the oleic series.

The combined shellac acids dehydrolized by hydrochloric acid, then extracted successively with boiling water, alcohol and ether left a residue

C. 67.87
H. 9.16

Besides these we find non-condensable acids, wax, coloring matter, etc. Iodine No. = 16.56. The non-condensable rosins of a good shellac possess a wax-like consistency and impart to the shellac elasticity, which cannot be accomplished by such rosins as pine rosin and similar hard alcohol soluble resins. These rather decrease the elasticity by distributing these good qualities of a normal shellac over a larger bulk. I examine, therefore, the physical properties of the non-condensable resins. They should show the consistency of a soft wax.

I have based upon these observations a method of analysis carried out in my laboratory for the past six years, which is as follows:

ANALYSIS.

Sand is incinerated for the destruction of organic material and subsequently extracted by hydrochloric acid, washed and dried and again ignited. This is far preferable to ground glass, which is partly dissolved by the H. Cl used in the subsequent treatment.

The shellac to be tested is always finely pulverized.

Two grams of shellac in a porcelain dish are intimately mixed with 10 grams of sand. The mixture is then moistened with about 4 c.c. of alcohol and shortly after with about 10 c.c. concentrated muriatic acid. Transfer to a water bath and evaporate to dryness. Repeat these manipulations once or twice and finally heat the dry residue in an air bath to 105 degrees C. for two (2) hours. After cooling add 20 c.c. 95% cold alcohol and let soak over night. Decant the alcohol through a filter into a weighed flask. The residue is then thoroughly disintegrated and repeatedly extracted by alcohol in 20 c.c. portions until the filtrate in the flask measures about 150 c.c. or more. If the alcohol is evaporated it leaves the rosins and fatty acids (not oxy acids) and not condensable by muriatic acid. If this residue is to be examined for pine rosin, dissolve some in concentrated sulphuric acid and sprinkle lightly upon it some cane sugar crystals.

In the presence of pine rosin at first a red violet coloration appears, which later becomes blue. Do not test the original shellac by this method.

These non-condensable rosins are those which mainly interest the merchants. They want to know how much of such incon-

densable rosins are present, or how much in excess of what is found in the best mark of commerce.

The best shellac contains about 8% of these non-condensable rosins, and anything in excess must be adulteration or show inferiority. Many have thought that the only thing of importance is the approximate determination of pine rosin or colophony, but my investigations have clearly shown to me that many brands of shellac with as much as 16% of alcohol soluble non-condensable rosins are perfectly free from pine rosin, while others containing no more are adulterated with pine rosin. Langmuir's iodine test exaggerates or diminishes the pine rosin present. So does McIlhenny's bromine method. For, for the same iodine number, we may calculate widely different rosin contents.

A shellac showing an iodine number = 71.62 contains according to Langmuir 25.5% rosin, but if we substitute the lowest or highest iodine Nos. of rosin in the calculation for actual rosin present, we obtain figures indicating 22% rosin or 34% rosin, a range of uncertainty amounting to 12%. Moreover, pine rosin is certainly not the only adulterant to be looked for.

If one contracted to furnish a shellac with no more than 20% rosin, to be determined by iodine absorption, one could easily add 5% and more in excess of one's contract and remain safe, provided one uses a pine rosin with a low iodine No. By my method this scheme is balked.

As said before, good pure shellac contains only about 8% of non-condensable and alcohol soluble rosin, salts, etc., yet I found shellacs which contain 16% of non-condensable rosins. These might be furnished from the plant upon which the insect is grown or might have been added. What we desire to know is the total of such not condensable rosins, or the excess over 8%. This non-condensable matter when obtained from the best shellac consists of about 15% of salt, alcohol and water-soluble organic matter derived from the shellac and 85% of resinous residue and fat.

A quantity over 8% of alcohol extracts is, however, not necessarily an adulterant. It is in part due to the manufacture of shellac from the crude material. This latter is packed in bagging, heated and pressed. The better shellac, the blond varieties, are obtained first. Reheating and additional pressure give higher colored varieties, which are also richer in this peculiar hard rosin found in shellac. They would, therefore, not be really

adulterated, but only indicate inferiority, though an addition of a similar rosin and not pine rosin is by no means out of the question. How much is due to the nature of the plants upon which the insect is grown cannot be determined here but only at the place of manufacture.

If the wax is to be determined this can be done in a separate portion, either by alcohol or by using a solution of carbonate of soda or caustic soda as the solvent and collecting the undissolved portion, which is the wax or myricyl alcohol.

The influence of hydrochloric acid incompletely removed from precipitated shellac also illustrates the formation of an alcohol-insoluble shellac after the same has been heated in boiling water and then spun and dried.

From the results obtained we calculate the actual addition of foreign rosins as follows:

Let the standard be 8% non-condensable matter and Y be the percentage quantity of such matter found in a shellac under examination. Then we have:

$(100 - 8) : 8 = (100 - Y) : X.$

and $Y - X$ is the quantity of non-condensable matter added to this shellac.

Say we find 13% non-condensable, then we have:

$92 : 8 = 87 : X.$ $X = 7.56\%$ due to the pure shellac in the mixture.

$13.00 - 7.56 = 5.44$ rosin added.

To test the method I used a shellac already adulterated giving non-condensable matter 12.22.

7.5 grms. of this shellac were melted together with 2.5 grms. of rosin.

From 1 gram of this mixture examined by my method 0.3425 were obtained as non-condensable. We then have

$87.78 : 12.22 = 65.75 : X;$ $X = 9.15.$

$34.25\% - 9.15\% = 25.1$ rosin added in place of 25% according to the mixture made, and in excess of the quantity already present.

I have been asked in all seriousness by so-called shellac experts, what is the use of examining shellac if not for pine rosin? If pine rosin were the only adulterant this question would be relevant. But pine rosin is not the only one, and it does not matter from the standpoint of the consumer or buyer

whether the resinous matter, in excess of a standard, is contained in the shellac as produced by the insect growing on a special plant or whether it has been added. This excessive resinous matter is harder and not wax-like and does not improve the shellac, and it is useless to ascertain its origin; it tends to deteriorate the shellac and should regulate the price downward.

To Mr. J. W. Paisley I herewith express my thanks for his valuable assistance.

Book Notices.

Gas, Gasoline and Oil Engines, including Producer-Gas Plants. A new, complete and practical work on gas, gasoline, kerosene, and crude petroleum engines, including producer-gas plants for gas-engine owners, gas engineers, and intending purchasers of gas-engines, fully describing and illustrating the theory, design, construction, and management of the explosive motor for stationary, marine, and vehicle motor power, by Gardner D. Hiscox, M.E. Including a list of United States patents issued on the gas-engine industry to the present time. A new book from cover to cover, entirely reset, revised, and enlarged. Illustrated by three hundred and fifty-one engravings. Fifteenth edition New York, Norman W. Henley, Publishing Co., 1906. 442 pages, 8vo. Cloth, price, $2.50.

The title fully describes the object of the work. The present edition includes the most recent information on the explosion motor and covers all branches of this growing industry.

The work will appeal to the gas engineer and all who are interested in this modern form of engine. The list of United States patents covers the subjects of gas, gasoline, and oil engines and their adjuncts from 1875 to date.

We also find here the rules and regulations of the Board of Fire Underwriters relating to the installation and management of gasoline motors.

R.

Resistenza dei Materiali e Stabilita delle Costruzioni ad uso degli Ingegneri, Capomastri costruttori, ecc. Ing. Dr. Guido Sandrinelli. Edizione completamente rinnovata del Manuale del defunto Pietro Gallizia. Manuali Hoepli. 471 pages, illustrations, 24mo. Milano, Ulrico Hoepli, 1905. Price, cloth, lire 5.50.

The engineer who has a working knowledge of Italian will find this little work useful. It is a reference book on the entire subject of the strength and resistance of materials in their relations to architecture and engineering. The writer has made free use of the standard works in other languages and has also drawn from the old Italian work of Pietro Gallizia. The result is a convenient little hand-book for the constructing engineer.

R.

La Ceramique Industrielle. Chimie-Technologie par Albert Granger. 644 pages, illustrations, 8vo. Paris, Gauthier-Villars, 1905. Price, cloth, 17 francs.

The work is a complete treatise on pottery, beginning with the raw material and taking the reader through the various stages to the finished product. Bricks, terracotta, earthenware, porcelain, all are treated. The chapters on coloring, glazing and enamels deal with the chemical as well as the practical side. The modern forms of ovens and kilns are described and illustrated.

The author has produced a convenient reference book, which is supplied with a good index and a brief vocabulary, in three languages, of the principal terms used in ceramics. R.

Experiments in Applied Electricity, by Arthur J. Rowland and William B. Creagmile. 181 pages, illustrations, 12mo. New York, McGraw Publishing Co. 1905. Price, cloth, $1.25.

This hand-book is intended to meet the wants of students in technical and manual training schools who have only a limited time to devote to the study of electricity.

The authors have had an experience covering several years, and while they have planned their little work to meet the needs, chiefly, of their own students of Drexel Institute, it can be introduced without inconvenience into any school where electricity forms a part of a course in physics. The experiments noted cover the subject of electrostatics, magnetism, battery and dynamo currents.

L'Année Technique, 1903-1904, par A. Da Cunha, préface par Henri Moissan. 303 pages, illustrations, 4to. Paris, Gauthier-Villars, 1904. Paper, price, 3.50 francs.

L'Annee Technique, 1905, par A. DaCunha, préface de Albert Dastre. 232 pages, illustrations, 4to. Paris, Gauthier-Villars, 1905. Paper, price, 3.50 francs.

These two volumes form a report of progress in the industrial arts of the world.

The subjects included are architecture and building, railroads and transportation, lighting and heating, and applied physics.

It is interesting to note the numerous reports on American achievements.

There are many good illustrations and the information is valuable. The series will be useful as a work of reference. R.

Die Hemmungen der Uhren, ihre Entwickelung, Konstruktion, Reparatur und Behandlung vor der Reglage, nebst zugehörigen Tabellen, zahlreichen Abbildungen und sechs Porträts. Allgemein verständlich für Uhr-Macher, Ingenieure, Techniker, u. s. w. bearbeitet von C. Dietzschold. 234 pages, illustrations, 8vo. Forming Vol. I of C. Dietzschold's Uhrmacher-Bibliothek. Krems a. D., the Author, 1905.

Horology has not been neglected by writers, but this is the first modern work which treats fully the subject of escapements. It covers development, construction, repairing, and handling, and describes all the important forms of escapements, historically, theoretically, and practically. The work is well illustrated and carefully printed. The author intends publishing, at in-

tervals of two or three months, a series of volumes covering all the branches of watch- and clock-making. The first volume is a good beginning, and it is hoped that the undertaking will receive sufficient encouragement to make it possible to continue the series until the entire field is covered. R.

Foods and their Adulterations; origin, manufacture, and composition of food products; description of common adulterations, food standards, and national food laws and regulations. By Harvey W. Wiley, M.D., Ph.D. 625 pages, 86 illustrations, 11 colored plates, 8vo. Philadelphia, P. Blakiston's Son & Co., 1907. Price, cloth, $4.00 net.

Dr. Wiley, in the preface of his new book, says in part: "This manual is descriptive in character and aims to give, within its scope, as thoroughly and intelligibly as possible, on account of the various food products in common use in their natural and manufactured conditions, with the usual adulterations which have been found therein. It includes information regarding Methods of Preparation and Manufacture, Food Values, Standards of Purity, Regulations for Inspection, Simple Tests for Adulterations, Effects of Storage, and similar matters pertaining to the subject. It has been designed to interest the consumer, as well as the manufacturer, the scientific as well as the general reader, all of whom it is hoped will find in it something useful. The consumer is entitled to know the nature of the product offered, the manufacturer and dealer the best methods of preparation. It will give the physician and sanitarian knowledge of the value of foods, their proper use and inspection, and, while not analytical in purpose, will provide the chemist with information which will guide him in his work of detecting impurities."

The crusade Dr. Wiley has made and is making in the interest of a nation fully aroused on the question of purer foods is well known. His extensive experience and the facilities he has at his command qualify him to write authoritatively and interestingly on this subject.

R.

Correspondence.

On the Speed of the Invisible Portions of the Spectrum. ADDITIONAL NOTE.

I desire to supply an unintentional omission in the Boyden Prize Memoir as published in the August number of the *Journal.* The reference is to the work of Hertz, who, in 1888, showed that the long electromagnetic etherwaves travel with a speed which differs from that of the visible light waves by less than one per cent., while their length is a million or more times as great. Our belief in the uniform speed of travel of the ultra red waves is therefore of the nature of an interpolation, while the similar assumption for the ultra violet waves was (until recently) an extrapolation.

PAUL R. HEYL.

The Franklin Institute.

(Proceedings of the stated meeting held Wednesday, September 18th, 1907.)

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, September 18th, 1907.

PRESIDENT WALTON CLARK in the chair.

Present, fifty members and visitors.

Additions to membership since last report, eleven.

The President called the attention of the meeting to the award of the Boyden Premium, which had been made by a committee of the Institute to Dr. Paul R. Heyl, of Central High School; and after expressing the satisfaction of the Institute at having been the instrument of executing Mr. Boyden's trust and at the award having been gained by a Philadelphia scientist, called upon the Secretary for a statement of the nature of the trust and the conditions of the award. The Secretary thereupon gave a detailed review of the entire subject.

At the conclusion of the Secretary's remarks he handed the President a certified check for the sum of One Thousand Dollars. The President then called Dr. Heyl to the floor, and after congratulating him on his achievement, formally presented the check to him. Dr. Heyl expressed his thanks and proceeded to give a description of the entire subject matter of his investigation. Dr. Heyl opened his remarks with a historical review of the status of the question propounded by Mr. Boyden at the time when the trust was instituted, in 1859; and noted that while the question was at the time one of the most mooted in physical science, it has since been relegated to one of secondary importance by the advance of science in general. There still remained, however, the requirement of a positive demonstration of the fact that had otherwise been determined by various analogies: that all rays of light and other physical rays travelled with the same velocity, and this demonstration he had been enabled to make photographically for the ultra-violet rays. Dr. Heyl's communication was mainly a popular statement of the data contained in his memoir on the subject already published and was illustrated with lantern slides and diagrams. At the conclusion of Dr. Heyl's discourse, in response to requests from the President, various aspects of the matter were reviewed successively by Dr. Robert Ellis Thompson, Principal of the Central High School; Prof. M. B. Snyder, Director of the Dept. of Physics; Prof. Harry F. Keller, Director of the Dept. of Chemistry, and Prof. Ernest Lacey, Director of the Dept. of English in the High School.

The President then introduced Mr. Louis Edward Levy, member of the Board of Managers, who, on behalf of the Institute, delivered a eulogy of the late Prof. Angelo Heilprin. During Mr. Levy's remarks a portrait of Prof. Heilprin was shown. Mr. Levy's remarks took the form of a memoir in which the life work of Prof. Heilprin was briefly reviewed.

At the conclusion of the meeting it was unanimously voted, on motion by Dr. Goldsmith, seconded by Dr. Williams, that Mr. Levy's paper be referred to the Committee on Publications with the recommendation that it be published in the *Journal.*

On motion, duly seconded, a vote of thanks was adopted and extended to the speakers of the evening, and the meeting was adjourned.

WM. H. WAHL, *Secretary.*

FRANKLIN INSTITUTE

Announcement

and

Program of Lectures

1907-1908

PHILADELPHIA: 15 S. Seventh St.

Issued October 1, 1907

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FRANKLIN INSTITUTE.

THE FRANKLIN INSTITUTE, OF THE STATE OF PENNSYLVANIA, FOR THE PROMOTION OF THE MECHANIC ARTS, was founded in the year 1824. The purpose of its founders is plainly set forth in its corporate title, and the means employed in the furtherance thereof are concisely stated in the following:—

LIBRARY.

At the present time the library contains 61,122 volumes, some 44,644 pamphlets, 2,939 maps and charts, and 1,250 photographs, classified and catalogued. It is exclusively scientific and technical in character and is steadily increasing in numbers and importance. It embraces, in addition to the standard and current works on mechanics, physics and chemistry, pure and applied, the publications of the principal scientific and technical societies of the world, files of 565 domestic and foreign scientific and technical serials, and sets of the British (and Colonial), French, German, Austro-Hungarian, Russian, Swiss, Finnish, and American patent records. The library is also designated under the Act of Congress as the repository of the Government publications of the Congressional District in which it is located. Special attention has been given for a number of years to the collection of

state and municipal reports relating to public works, water supply, sewerage, health, reports of railway and other important corporations, etc., which are rarely preserved in complete form in libraries, on which account this branch of the library has become extremely valuable. The extent and general state of completeness of the above-named official publications, and especially of the serials, make this collection particularly useful as a reference library.

The library is open as follows: Mondays, Tuesdays, Wednesdays, Fridays, 9 A.M. to 6 P.M.; Thursdays, 9 A.M. to 10 P.M.; Saturdays. 9 A.M. to 5 P.M.; third Wednesday of each month 9 A.M. to 10 P.M. (5 P.M. from June 1st to September 16th; Saturdays, 12 M.) The library is closed on Sundays and on state and national holidays.

It is accessible to members in good standing for use and reference at all times, between the hours above named; and to the public, *for reference to public documents only*, between the hours of 10 A.M. and 3 P.M. A Librarian, with several assistants, is in charge of the library, under the general direction of the Secretary and the Committee on Library.

(Members are requested to present to the library copies of books, magazines, and pamphlets which they do not wish to preserve. A card addressed to the Librarian, notifying him when and where to send for such gifts, will receive prompt attention.)

LECTURES.

Formerly it was customary for the Committee on Instruction, with the co-operation of the professors, to arrange each year a course of about twenty-five lectures of a scientific or technical character. Experience has demonstrated, however, that it would better meet the general wish of members to restrict the Institute lectures, as far as practicable, to such as can be made attractive and entertaining, especially by means of illustrations.

The program of the Lecture Course for the season of 1907-1908 will be found elsewhere.

SCHOOLS.

The Institute maintains the following technical schools, viz:—

A Drawing School, embracing instruction in Mechanical, Architectural, and Free-Hand Drawing.

A School of Machine Design, embracing Elementary Mathematics and the Principles and Application of Machine Design.

A School of Naval Architecture, embracing Theoretical Naval Architecture and the Design and Construction of Ships.

The sessions of these schools are held *in the evening*, in order to give young men engaged in workshops and elsewhere during the day, the opportunity of profiting by them without interference with their daily occupation.

There are two courses (winter and spring) of three months each; the first beginning about the middle of September and ending in December; the second, from January to the middle of April.

Applicants for admission to the schools may obtain a special circular giving a synopsis of the several courses of instruction, details of the term periods of the classes, the school evenings, price of instruction, etc., by applying at the office of the ACTUARY, in the HALL OF THE INSTITUTE, 15 SOUTH SEVENTH STREET.

A general account of the character of the work of the schools is given herewith:—

Drawing School.—A school of instruction in Drawing, embracing the Mechanical, Architectural and Free-Hand branches, has been maintained uninterruptedly since the foundation of the Institute. It is in charge of a Director and several assistants, under the general direction of the Committee on Instruction, and at present is in a flourishing condition, both in respect of the means and methods of instruction and the number of its pupils.

School of Machine Design.—The aim of this school is to bring within the reach of draughtsmen, practical mechanics and others interested in the design of machinery, who have not found the opportunity of a technical education, a systematic and logical exposition of the principles and application of machine design, under conditions that require no interruption of their business pursuits. This was originally sought by establishing the School of Elementary Mathematics, in which the necessary preliminary training in mathematics was offered. During the two years of its existence as a separate school, a demand arose for a definite course in machine design, which has been met by merging the mathematical course with the subjects which comprise a course in machine design.

The full course extends over four years.

The first two years of the course are devoted exclusively to Mathematics, after which Theoretical Mechanics, Strength of Materials, Machine Design and Kinematics of Machinery are discussed as scheduled in the synopsis. Instruction will be carried on by lectures, illustrated by blackboard demonstrations and the solution of numerical problems. In addition, test and drill problems, to be solved out of class, will be assigned. The latter part of the work in Machine Design will consist in computing the proportions of some machine of standard type and preparing complete working drawings from them. In Kinematics of Machinery, also, drawing-board problems will form an essential part of the work.

For the best results and most general and satisfactory treatment of these subjects, an elementary knowledge of the methods of the Differential Calculus is desirable, in fact, almost indispensable in the discussion of certain theorems in applied mechanics, though in most cases it can be replaced by special methods involving

only elementary mathematics. These special methods will be freely used, but an attempt will be made to gradually introduce the more advanced and logical method in the discussion of the technical subjects, and in the future to make place for it—when it can be treated more thoroughly—in the mathematical course.

Those who have satisfactorily completed the full course will be awarded a certificate of study. Those who complete the mathematical work only, may receive a certificate covering that branch.

School of Naval Architecture.—The scope of this school as at present organized covers Theoretical Naval Architecture and Ship Design and Construction. It is contemplated in time to extend the course of instruction to embrace also the subject of Marine Engineering. The courses are so devised and arranged as to meet in the most practical way the needs of the young men engaged in the shipyards who may wish to qualify themselves for the higher branches of the ship-builder's art.

JOURNAL OF THE FRANKLIN INSTITUTE.

The Franklin Institute began, in the year 1826, the publication of a *Journal*, devoted to Science and the Mechanic Arts, which has been continued uninterruptedly to the present day. It contains the record of the scientific and other useful work of the Institute, besides many valuable contributions relating to the growth of American industries and the progress of science and the useful arts in general during the past three-quarters of a century.

The *Journal* has an acknowledged position at home and abroad as a standard work of reference.

The complete file of the *Journal* embraces: The *Franklin Journal* (4 vols.), 1826-1827; the *Journal of the Franklin Institute*, second series (26 vols.), 1828-1840; the *Journal of the Franklin Institute*, third series (134 vols.), 1841 to the present; or 164 volumes in all.

In its present form the *Journal* is an octavo of 80 pages. It is issued monthly. The six issues of each half year (January to June, and July to December) constitute a complete volume, with index and title-page.

The *Journal* is edited by a Committee on Publications with the assistance of the Secretary of the Institute. The subscription price is *Five Dollars* per year. *The Journal is sent to all members in good standing without charge.*

The first part, embracing the first 120 volumes (1826-1885), is sold at *Five Dollars.*

The second part (1886-1895) is sold for *One Dollar and Fifty Cents.* Sent post-paid on receipt of price.

A third part (1896-1905) is now in press.

MEETINGS OF THE INSTITUTE.

The Institute meets on the *Third Wednesday* of each month (except in July and August). At these meetings papers on important scientific and technical subjects are read and discussed, or new inventions are exhibited and described, or a report on current matters of interest in science and the useful arts is presented by the Secretary. The meetings are held in the Lecture Room. The chair is taken at 8 o'clock P.M. Members may introduce friends. Visitors are requested to leave their cards with the doorkeeper. On meeting evenings the Reading Room will remain open until 10 P.M.

COMMITTEE ON SCIENCE AND THE ARTS.

This Committee was originally the Committee on Inventions. It was formed in 1834, and from that date to the close of 1886 was constituted of volunteer members. At present the Committee consists of sixty (60) members, chosen at the annual election, twenty each year, who pledge themselves to investigate and report upon the merits of such inventions as may be submitted to them for that purpose, and to perform such other duties as may be referred to the Committee by the Institute. In its time this Committee has examined and reported upon a great number of inventions, and many worthy persons are indebted to its counsel and aid for the successful introduction of their inventions, or have been dissuaded from wasting time and money upon impracticable ideas. It has investigated and reported upon numerous subjects referred to it by the Institute, and by its labors has assisted notably in maintaining the scientific reputation of the Institute. The work of the Committee on Science and the Arts is done gratuitously. The meetings of this Committee are open to all members of the Institute.

This Committee has been intrusted by the Institute with the authority to grant the *Elliott Cresson* Gold Medal and the *Edward Longstreth* Medal of Merit, and to recommend the grant of the *John Scott Legacy* Premium and Medal, for discoveries and inventions of conspicuous merit.

Persons desiring to submit their inventions to this Committee will be furnished by the Secretary with a printed copy of the rules and a blank form of application.

(A list of the Committees as at present constituted appears elsewhere).

SECTIONS.

Members of the Institute who may wish to become associated in order to devote themselves to special branches of science and the useful arts may organize a Section for that purpose, in accordance with certain prescribed regulations. (*See the By-Laws.*)

The By-Laws provide that "*all members of the Institute shall have the privilege of enrolling them-*

selves without payment of additional fees, as members of any of the Sections which are now, or which may hereafter be established."

At the present time there are in existence five Sections, to wit, a Section of Physics and Chemistry, Section of Photography and Microscopy, an Electrical Section, a Mining and Metallurgical Section, and a Mechanical and Engineering Section, having a combined membership of about three hundred. The meetings of the Sections are held in the Hall, and *are open to all members of the Institute.*

The Sections meet on each *Thursday evening of the month* at 8 o'clock (except in July and August). These meetings are devoted principally to reading and discussion of papers on original investigations germane to the objects of the Sections. A list of communications thus far arranged by the Sections appears elsewhere. Members enrolled in the Sections receive special card notices announcing the program of each week. Special meetings will be specially announced. On meetings nights the Library is open until 10 P.M.

EXHIBITIONS.

The first exhibition of American manufactures in the United States was held, under the direction of the Franklin Institute, in the year 1824, in the old Carpenter's Hall, in Philadelphia.

Since that notable event the Institute has held twenty-nine exhibitions. The last was the National Export Exposition, held in 1899 in co-operation with the Philadelphia Commercial Museum.

SCHEDULE OF MEETINGS.

1907-1908.

(Institute and Section meetings are all held on WEDNESDAY and THURSDAY evenings, except when these fall on legal holidays.)

First Wednesday of each month (except July and August), at 8 P.M.

COMMITTEE ON SCIENCE AND THE ARTS.

Second Wednesday of each month, at 1.30 P.M.

BOARD OF MANAGERS.

Third Wednesday of each month (except July and August), at 8 P.M. INSTITUTE.

Thursday evenings, 8 o'clock (except in July and August.) GENERAL SECTION MEETINGS.

1907	Committee on Science and the Arts	Board of Managers	Institute
October	2	9	16
November	6	13	20
December	4	11	18
1908			
January	.	8	*15
February	5	12	19
March	4	4	18
April	1	8	15
May	6	13	20
June	3	10	17
July	.	8	..
August	.	12	..
September	2	9	16

Thursday evening of each week, 8 o'clock, except in July and August. } Section meeting.

*The Annual Meeting.

MEMBERSHIP.

TERMS AND PRIVILEGES.

The members of the Institute are divided into the following classes, viz.: *Contributing Members, Stockholders, Life Members, Permanent Members,* and *Non-resident Members.*

Any person of legal age friendly to the mechanic arts is eligible to membership in the Institute. Candidates must be proposed by a member in good standing, and elected by the Board of Managers.

Terms.—Contributing members pay Fifteen Dollars each year. The payment of Two Hundred Dollars in any one year secures Life Membership, with exemption from annual dues.

Stock.—Second-class stockholders pay an annual tax of Twelve Dollars per share, and the holder of one share is entitled by such payment to the privileges of membership.

Privileges.—Each contributing member (including non-residents) and adult holder of second-class stock is entitled to participate in the meetings of the Institute, to use the Library and Reading Room, to vote at the Annual Election for officers, to receive tickets to the lectures for himself and a lady, to attend the Section meetings and to receive one copy of the *Journal free* of charge, and additional copies at Three Dollars per year.

Permanent Members.—The Board of Managers may grant to any one who shall in any one year contribute to the Institute the sum of One Thousand Dollars a permanent membership, transferable by will or otherwise.

Non-resident Members.—Newly elected members residing permanently at a distance of twenty-five miles or more from Philadelphia may be enrolled as Non-resident Members, and are required to pay an entrance fee of Five Dollars, and Five Dollars annually. Non-resident Life Membership, $75.00.

Contributing members, if eligible, under the non-resident clause, on making request therefor, may be transferred to the non-resident class by vote of the Board of Managers, and are required to pay Five Dollars annually.

Resignations must be made in writing, and dues must be paid to the date of resignation.

MEMBERSHIP BADGES.

The design of the Institute's membership badge is circular in form, with a diameter equal to that of a dime. In the center, in high relief, appears a profile bust of Benjamin Franklin, a reduced copy of that used on the Franklin Institute Medal. Surrounding the bust is a ribbon of blue enamel, inscribed in which are the words: "Franklin Institute, 1824." The finish is blue and gold, the metal work being thoroughly and heavily plated with gold, and all work done in a first-class manner.

The Board of Managers has fixed the price of the badge, to members in good standing, at $1. It may be had either in the form of a button, a pin or a pendant. In solid gold the price is $5. All badges are numbered, and the owner's name and number recorded.

CERTIFICATE OF MEMBERSHIP.

Certificates of membership of handsome design, suitable for framing, 19 x 24 inches in size, may be purchased by members in good standing at the price of $1.

PROGRAM OF LECTURES.

SEASON 1907-1908

To be delivered in Lecture Hall, Franklin Institute, 15 South Seventh Street.

LECTURES BEGIN AT 8 O'CLOCK P.M.

☞The Committee on Instructions expects to arrange for the season 1907-1908 a series of *six (6) profusely illustrated popular scientific lectures*, which will be delivered in the Lecture Hall of the Franklin Institute.

The list (subject to change) is as follows:—

1907 (First Series.)

AUTUMN COURSE, 1907.

Friday, November 1st, DR. THOMAS E. WILL, Secretary American Forestry Association, Washington, D. C.
Forestry; with Especial Reference to the Appalachian Natural Forests.

Friday, November 15th, DR. HENRY LEFFMANN, Philadelphia, Pa.
Diamonds and Diamond Mining.

Friday, November 29th, DR. FULLERTON L. WALDO, Secretary of the Civil Service Reform Association of Pennsylvania.
The Panama Canal.

1908. (Second Series.)

Winter Course.

The definite arrangement of these lectures to be given in January and February, 1908, will be announced later in the season.

Provisional engagements (subject to change), have been made with the following lecturers:—

Friday, January 31st, Andrew Wright Crawford, Philadelphia, Pa.
The Proposed Boulevard for Philadelphia.

Friday, February 14th, Persifor Frazer, Dr. ès Sci. Nat., Philadelphia, Pa.
Subject to be announced.

Friday, February 28th, Paul A. Spencer, A.B., M.E., Philadelphia, Pa.
Long-Distance Electric Transmission.

Notice.—Admission to these lectures will be reserved to members of the Institute and friends. Members will be admitted to the Lecture Hall on presentation of their membership ticket, which will admit *member and friends*.

PRELIMINARY
PROGRAM OF THE SECTIONS

1907-1908.

A preliminary list is presented herewith of Section papers and communications. This will be supplemented from time to time by the Executive Committees of the Sections as additional arrangements are made.

By unanimous vote of the Executive Committee of the several Sections, Thursday Evening of each week during the season excepting legal holidays, is designated as Section evening. Each Section in turn will arrange the weekly program, and members of all the Sections will meet weekly in joint session.

Members of the Sections will receive due notice of the Thursday evening meetings.

[Members of the Institute have the privilege of attending all meetings of the Sections.]

1907-1908.

The Pitometer.
Edward S. Cole, Manager The Pitometer Co., New York.

The Electrothermic Production of Iron and Steel.
Dr. Joseph W. Richards, Lehigh University, Bethlehem, Pa.

Automatic Telephone Systems.
J. W. Lattig, Vice-Pres. and Gen'l Mgr. The American Telephone Co., Rochester, N. Y.

Wood Turpentine and its Derivatives.
F. P. Veitch, U. S. Dept. of Agriculture, Washington, D. C.

Moving Pictures and How they are Made.
S. Lubin, Philadelphia, Pa.

The Jerseyite.
Dr. Edward Goldsmith, Philadelphia, Pa.

Some Recent Work in Metallography.
Dr. Wm. Campbell, Columbia University, New York.

The Mercury Arc.
F. H. Von Keller, Manager, Cooper-Hewitt Electric Co., New York.

An Improved Range Finder.
Lowndes Taylor, West Chester, Pa.

Improved Instruments for Navigation.
Dr. Henry Emerson Wetherill, Philada.

The Present Status of Sewage Disposal.
George A. Johnson, Sanitary Eng., New York.

Electrical Measurement Apparatus.
E. F. Northrup, The Leeds & Northrup Co., Philadelphia, Pa.

Steel Rails.
Discussion opened by Robert Job, Philada.

Radio-Active Minerals in Pennsylvania.
Edgar T. Wherry, Ph.D., Philadelphia, Pa.

The Medical Uses of the X-Rays.
Wm. S. Newcomet, Philadelphia, Pa.

Development in Turbine Design.
Richard H. Rice, Gen'l Electric Co., West Lynn, Mass.

Gas and Gasoline Engines.
H. S. Baldwin, Eng. Dept. Gen'l Electric Co., West Lynn, Mass.

Protective Coatings: Failures and Successes.
G. B. HECKEL, Sec'y of the Paint Mfr's Association of the U. S., Philadelphia.

Corrosion of Iron and Steel.
ALLERTON S. CUSHMAN, U. S. Dept. of Agriculture, Washington, D. C.

Effect of Smelter Fumes on Vegetable and Animal Life.
J. K. HAYWOOD, U. S. Dept. of Agriculture, Washington, D. C.

The Revolutionizing of Electric Domestic Lighting.
F. M. F. CAZIN, Hoboken, N. J.

The Supposed Transmutation of the Elements.
DR. H. F. KELLER, Central High School, Philadelphia, Pa.

Vanadium in Steel.
DR. RICHARD MOLDENKE, Sec'y Am. Foundrymen's Association, Watchung, N. J.

Experiments with Sand Filtration.
W. B. FULLER, Dept. of Water Supply, Gas and Electricity, New York.

Scamoni's Contributions to the Development of the Modern Graphic Arts.
LOUIS E. LEVY, Philadelphia, Pa.

Recent Developments in Wireless Telegraphy and Telephony.
C. D. EHRET, Counsellor-at-Law, Philada.

Working Standards of Light and their Use in Photometry.
CHAS. O. BOND, Chief Photometrist, United Gas Imp't Co., Philadelphia.

Deflocculated Graphite.
E. G. ACHESON, Niagara Falls, N. Y.

Recent Developments in the Metallurgy of Zinc.
W. McA. JOHNSON, New York.

The Telepost.
PATRICK B. DELANEY, New York.

Reinforced Concrete and its Use in Construction.
RICHARD L. HUMPHREY, Philadelphia, Pa.

The Equipment of Country Houses and Farms with Electricity.
PUTNAM A. BATES, Consulting Electrical Engineer, New York.

Some Practical Investigations into the Character Structure and Uniformity of Mild Steel.
CHAS. L. HUSTON, Vice-Pres. Lukens Iron and Steel Co., Coatesville, Pa.

Cement: Its Use and Abuse.
Robt. W. Lesley, Philadelphia, Pa.

Solid Steel Ingots.
N. Lilienberg, Metallurgical Engineer, Philadelphia, Pa.

The Process and Apparatus for the Production of Carbon di Sulphide in the Electric Furnace.
Edward R. Taylor, Penn Yan, N. Y.

Maple Products.
Albert P. Sy, Buffalo, N. Y.

The Electron Theory.
Dr. Edward A. Partridge, Central Manual Training School, Philadelphia, Pa.

The following speakers will announce the subjects of their communications later on:

Dr. Henry Leffmann, Consulting Chemist, Philadelphia, Pa.

James Christie, Mechanical Engineer, Phila.

G. H. Clamer, Metallurgical Engineer, Phila.

Francis A. J. FitzGerald, Elec. Engineer, Niagara Falls, N. Y.

Wm. J. Hammer, Electrical Engineer, New York.

Dr. Robt. H. Bradbury, Southern Manual Training School, Philadelphia.

H. Clyde Snook, Roentgen Mfg. Co., Phila.

Rich'd H. Edmonds, Ed. "The Manufacturers' Record," Baltimore, Md.

J. W. Ridpath, Jenkintown, Pa.

Dr. Chas. F. Himes, Carlisle, Pa.

Prof. Wilbur M. Stine, Swarthmore Pa.

The following named gentlemen have authorized the announcement of their names as probable contributors:

Dr. Geo. F. Stradling, N. E. Manual Training School, Philadelphia, Pa.

R. Fleming, Electrical Engineer, Gen'l Electric Co., West Lynn, Mass.

Cassius E. Gillette, Consulting Engineer, Philadelphia, Pa.

Geo. W. Sargent, Carpenter Steel Co., Reading, Pa.

Albert Sauveur, Cambridge, Mass.

Communications are also expected from the Professors and Lecturers of the Official Staff of Instruction of the Institute.

Angelo Heilprin

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FOR THE PROMOTION OF THE MECHANIC ARTS

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The Franklin Institute is not responsible for the statements and opinions advanced by contributors to the *Journal.*

THE FRANKLIN INSTITUTE.

(*Stated meeting held Wednesday, September 18th, 1907*)

In Memoriam

ANGELO HEILPRIN.

Memorial Address delivered before the Franklin Institute September 18th, 1907

BY LOUIS EDWARD LEVY.

Through the death of Professor Angelo Heilprin, on the 17th of July last, the Franklin Institute lost not only one of its most distinguished members, but also one of the most welcome of its frequent lecturers and, in common with the world of science generally, a recognized leader in the search for knowledge. While Professor Heilprin's researches dealt primarily with the natural sciences, their results led, as does every enlargement of our

knowledge, to a better understanding of our true relation to surrounding nature and a clearer comprehension of its workings. Applied to our daily life, this deeper insight into the facts of nature brings us to a more normal attitude towards its varying manifestations and enables us to deal more effectively with its various forces.

No better illustration of these conditions need be cited than that presented by the paramount influence of Professor Heilprin's work in determining the location of the inter-oceanic canal across the Isthmus of Panama, instead of along the more facile and in certain other respects more desirable route through Nicaragua. The respective merits and difficulties of these two routes had been debated for years by experienced engineers, by learned geologists, by journalists and by statesmen, and when the choice was finally to be made by act of Congress, the Senate wavered in its decision, many of its members remaining undecided in their opinion. At this juncture Heilprin, then investigating the volcanic conditions attending the catastrophe at Mont Pelée, announced his conclusions through the Philadelphia *Press*. In a telegram to that journal he said:—"My studies of what has happened here throw added light on the Isthmian Canal question. The catastrophism here is without parallel. Its relation with conditions at St. Vincent establishes the certainty of a long volcanic circuit, whose existence should dispose of Nicaragua as a canal route." His telegram closed with the statement that "The facts all prove the broad reach of volcanic force, and that reliance for the protection of a canal running through a volcanic country like Nicaragua, on the localization of volcanic force, its assumed dormancy, or the resistibility of the canal to its destructive action, is absurd."

The effect of this announcement was decisive. It brought conviction to the minds of Senators who had remained unconvinced by the arguments presented by Senator Hanna and other leading advocates of the Panama route, and left the Nicaragua project but a small minority of supporters, headed by Senator Morgan of Alabama. But it was not only in Congress that Heilprin's authoritative announcement brought conclusion to this much vexed question. His investigations influenced public opinion on the subject throughout the country and settled it permanently in favor of the Panama route.

"It is characteristic of Professor Heilprin," says *The Press* in its recent chronicle of the scientist's death, "that in this, as in other matters, he profited not a penny, though in the final transfer of the Panama interests to the United States, many men obtained millions for services of a trifling character compared with those which he had rendered." Absolute disinterestedness was not, however, the only shining quality of Heilprin's character. He was as blithe and genial as he was earnest and resolute, as modest and unassuming as he was fearless and determined. In the pursuit of his investigations, whether in the fire-scathed ruins of St. Pierre or amid the icy wastes of the frozen north, or surveying the plateau of Mexico from the snow-capped summit of Orizaba, Heilprin's purpose was simply that of the student scientist, whose function is first of all to bring to light the truth. It was for this that he repeatedly climbed Pelée and with death and destruction threatening close about him made a deliberate and careful study of its fiery outpour while the volcano raged in all its fury and was going, as he himself expressed it, "in full blast."

In a volume entitled "Mont Pelée and the Tragedy of Martinique," the story of his findings is simply but graphically told.

As he had pressed into the stormy wastes of the Arctic wilderness in search of Peary ten years before, he in this wilderness of fire pressed farther and farther toward the summit of the volcano, until he stood high among the clouds, amid lightning flashes and rolling thunder, and under a torrent of rain, with the outpour from the crater blackening the air about him and his few companions, and, in his own words, "as an unseen neighbor of one of the mightiest destroying engines of the globe." On the first ascent the rain storm forced him to retire, but on the following day, with George Kennan, Jaccaci and Varian, he ascended again and pushed through a scorching heat to within four feet of the fiery abyss, standing on a foothold of the stability of which he knew nothing and looking directly down into the crater's mouth. Kennan, in his report of the ascent, remarks: "I must pay the highest possible tribute to Heilprin. He is modest and brave, a superb mountaineer and the nerviest and pluckiest man I ever knew. The ascent was the most terrifying experience of my life." In his own narrative Heilprin says: "I felt that finally I had stood over Nature's great laboratory and been permitted to study some of its workings. Many years be-

fore, on Vesuvius, I had gazed into the crater funnel and watched the molten magma of the earth rise and fall, but the scene was one which could not compare with this, grand and inspiring though it was."

This was on the first of June, 1902. On the 30th of the following August, Heilprin made another ascent of the mountain with a view to determining the nature of the cone that was then apparently developing in the midst of the volcano's crater. He was accompanied by Julian Cochrane and by a number of native carriers. As they approached the summit the party was halted by a fusilade of exploding bombs horizontally shot out from the roaring column of steam and incandescent scoria that was being intermittently belched out from the seething crater, miles high into the air. Leaving his companions, Heilprin pushed upward to a point just below the crater's rim, crouching on the palpitating ground for all possible safety, and there made his observations amid the crash and roar of the terrific phenomena which he was studying. That night, after his return to the base of the mountain, the tragedy of St. Pierre was repeated all about him. A scorching blast, like that of the fatal 8th of May, was shot downward from the fiery summit of Pelée, sweeping through the nearby villages of Morne Rouge and Ajoupa Bouillon, carrying destruction to everything in its path and death to fully fifteen hundred of their inhabitants. The scientist, housed in a depression nearer the mountain's base, was fortunately beneath the line of the fiery discharge and so escaped with his life.

The phenomena of vulcanism, the tremendous outrush from mountain tops of fire and molten rock, the bursting forth of vast columns of flaming gases, of steam and of smoking scoriæ, have been a source of terror to the inhabitants of surrounding districts and a focus of allurement for philosophers and scientists from the dawn of history to the present day. It is remarkable that the two principal volcanos of Europe, Ætna and Vesuvius, have become historically signalized through two of the great scientists of classic antiquity having perished while studying their eruption. Empedocles, the half-deified Greek philosopher of Sicily, lost his life while investigating an eruption of Mt. Ætna in 430 B. C., his fate betokened only by the remnants of his brass sandals, and five centuries later, in the year 79, the great Roman naturalist, Pliny, hastened from a place of safety to study

the eruption of Vesuvius, and was suffocated by the sulphurous gases from the mountain while the neighboring cities of Pompeii and Herculaneum were being buried by its fiery outpour. And, now, in our own time, over eighteen centuries after Pliny's memorable dying day, another volcanic eruption, the most woefully tragic since that time, burst through the long-slumbering craters of the Carribean Islands and with the record of that catastrophe and the story of the destruction of St. Pierre, the name of another devoted scientist, Angelo Heilprin, will go into history. But this time, fortunately for the advancement of science, as well as for the explorer himself, the life of the intrepid student was not sacrificed in the quest, and the sum of human knowledge regarding the nature of volcanic action—a quantity remarkably small in comparison with the gains of science generally—has been augmented by the contributions of a keen and competent observer, made, not from some neighboring point of vantage, but on the very edge of the fire-belching chasm itself.

Those memorable explorations, now become historic, not only because of their singularity but also because of the far reaching importance of their results, were followed by yet other expeditions to the same locality, in the course of which Heilprin made a close study of the unique phenomenon which reached its full development in the later stages of the volcano's activity. This was the remarkable Tower of Pelée, so called by Heilprin and first observed by him on his ascent on August 30th and afterwards determined by him to be a mass of solidified magma, which, according to his latest investigations, was simply the mass of cooled material remaining as a core in the funnel of the volcano after its eruption in 1851. This core, pushed up through the crater by the gathering pressure of the volcanic forces from below, was gradually projected vertically outward until it towered more than one thousand feet above the crater, finally toppling in successive masses over the mountain side.

No similar phenomenon has ever before been recorded in history. It was this core of solid magma, choking the throat of the volcano, that prevented the eruption at the beginning from following a normal course in the vertical direction, and by causing the pent-up and super-heated gases to burst forth in a horizontal discharge, which unhappily was in the direction of St. Pierre, brought about the destruction of that city and the almost instant

death of all its 30,000 inhabitants. The downward blast of August 30, which so fatally swept through the neighboring villages. was due to the same cause. Heilprin's investigations of the phenomenon presented by this obstruction have thrown new light on the history of the Vesuvian eruption of the year 79, which in many of its aspects, as reported by the younger Pliny, and as further revealed by the excavations at Pompeii, had hitherto remained inexplicable. In the second of his books on the Martinique disaster, published in 1905 under the title of "The Tower of Pelée," Professor Heilprin has treated this subject, both as scientist and as historian, with lucid understanding and with a graphic hand.

Heilprin's investigations of volcanic phenomena were but part of a series of similar explorations in other fields of scientific research. These began at a very early stage of his career, in fact, during the intervals in his educational courses. His earliest predilections had been in the direction of natural history, and though he eventually developed considerable mastery as a painter and had also a marked talent as a musician, his controlling bent was to the study of science for the sake of knowledge alone, and for that he evinced from the beginning a readiness to adventure whatever it demanded or wherever it called.

Angelo Heilprin was born in Hungary, March 31st, 1853. His talents were inherited, his grandfather, Phineas Mendel Heilprin (1801-63), having been a recognized authority in Hebrew literature and a close student of the Kantian philosophy among the writers and scholars of the earlier half of the 19th century, and the Professor's father, Michael Heilprin (1823-88), having in his turn achieved high rank among the erudite scholars of his generation as a Biblical exegetist and literary critic. The grandfather, fleeing from Russian tyranny in his native Poland, had been compelled to take refuge in Hungary; the father had become associated with Kossuth during the struggle for freedom in the revolution of 1848 and had been compelled in his turn to flee before the Austrian conqueror. In common with other leaders of that rising, Michael Heilprin made his way to America, reaching this country with his family in 1856 and settling in Philadelphia. Two years later the family moved to Brooklyn, and there in 1860 Angelo Heilprin's education was begun in a public school. This training, however, but supplemented the

educational influences of his home. There his innate impulse towards the study of natural science was emphasized by the teachings of his learned father and under that influence young Heilprin's receptive mind rapidly compassed a wide domain of knowledge. Even before his 20th year he had become a capable associate, along with his elder brother, Louis Heilprin, in the work of their father as revising editor of the American Cyclopædia, he himself adding a number of original articles, notably the biographical sketch of John Tyndall. In his 24th year, in 1876, he went to London to take up the study of the natural sciences at the Royal School of Mines, now known as the Normal School of Science. There he learned his way in biology from Huxley, in palæontology from Etheridge and in geology from Judd, his efforts gaining for him the award of the Forbes medal for proficiency in the two former of these branches. Thereafter he studied in Paris; later journeyed on foot through the Swiss Alps and learned what he could of their glaciers, and then spent some eight months at Geneva, attending the lectures of Professor Carl Vogt and studying at the Natural History Museum in that city. From there he made his way through Italy, delving everywhere to add to his store of knowledge, and after a prolonged journey turned back through the Tyrolean Alps to Vienna and thence to Hungary, all on the same quest. After a time spent in Russian Poland, completing a three years' stay in Europe, he returned to America in June, 1879, having developed in his own original manner his gift of critical and accurate observation.

Soon after his return began his connection with the Academy of Natural Sciences of this city and his permanent residence here. In January, 1880, he was awarded the Jessup Fellowship of the Academy and by the end of the year his original contributions to its publications led to his election as Professor of Invertebrate Palæontology by that institution. Three years later, in October, 1883, his abilities were further recognized by the Academy through his election as one of the four members of its Board of Curators, and soon thereafter followed his appointment by the Council of the Academy as Curator in Charge.

In this position, which he held until his resignation in 1892, Prof. Heilprin was soon confronted with the difficulties incident to a lack of adequate room for the proper arrangement and display of the growing collections of the Academy, many of which

had of necessity to be stored out of sight. He took a leading part in a movement for the erection of an annex building to house the museum, and when eventually the Academy appealed to the State for financial aid to this end, Heilprin's eloquent address to the Legislature and his personal appeals to many of its individual members, were largely instrumental in obtaining the two appropriations of $50,000 each which were voted to the Academy in 1889 and 1891.

Soon after taking up his residence in this city Heilprin was impelled, through his studies at the Academy, to undertake the task of making a general and systematic review and analysis of the tertiary geology of each of the several States of the Atlantic and Gulf borders where that formation had been recognized. The results of his research were embodied in a series of notable papers, printed in the *Quarterly Journal* of the Academy, and in 1884 these papers were collected and with various later additions were published in book form under the title of "Contributions to the Tertiary Geology and Palæontology of the United States." The *American Journal of Science* characterized the work as "of great service to American geology."

There was next published, in 1885, "Town Geology: The Lesson of the Philadelphia Rocks. Studies of Nature Along the Highways and Among the Byways of a Metropolitan Town." It was a printed issue of the author's field lectures upon the geology of Philadelphia. Said the *Popular Science Monthly* in reference to it: "The present volume is an admirable exemplification of the true method of geological study. The author takes up features with which all Philadelphians are familiar and in which they may, therefore, be assumed to have a certain degree of interest, and connects them in a very simple and instructive way with the great body of geological truths in which these facts find their explanation. * * 'White Marble Steps and Window-Facings,' 'Brownstone Fronts and Jersey Mud,' 'Philadelphia Brick and Cobble-Stone,' are the familiar texts used by the author to interpret the wonderful workings of Nature in the immeasurable past, which, through long chains of causes and effects, have given rise to the present order of things."

In that year—1885—the Wagner Free Institute of Science, then reorganized under the will and bequest of its beneficent founder, Dr. William Wagner, called Professor Heilprin to con-

duct its courses in geology. By a special arrangement with the Academy he was enabled to undertake this work and continued it until 1890. In 1888 he accepted also the duties of Curator of the institution and thoroughly rearranged its museum.

It was soon after he became connected with the Wagner Institute and under the joint auspices of that organization and the Academy of Natural Sciences, that Heilprin began that series of scientific explorations which have so greatly distinguished his career, and which have added so largely to our store of accurate knowledge in various of the natural sciences. In 1886 he organized and led an expedition to the wilds of Florida, of which but little accurate information was then accessible, and that little yet awaited confirmation. The fauna of the seashore and of the interior lake region had not up to that time been closely investigated and proved a fertile source of new scientific data.

An important result of this exploration was the complete disproof of the previously accepted theory that the peninsula was of coraline formation, Heilprin's investigations bringing to light the fact that notwithstanding the indications furnished by the coral fringe along the coast, the body of the peninsula presents a sedimentary calcareous structure. The report of this expedition, with an introduction by Dr. Joseph Leidy, President of the Academy, was published in 1887 as the first volume of the Transactions of the Wagner Institute, the work being entitled "Explorations of the West Coast of Florida and in the Okeechobee Wilderness." Dr. Leidy in his introduction notes that "The well-observed facts of the report must greatly modify the opinions which have generally been held in regard to the geological construction of the Peninsula of Florida, and altogether Professor Heilprin's researches must be considered as an important contribution to science."

Heilprin's extraordinary activity and his large possession of that capacity for concentrated effort which has been recognized as the most sterling of all the forms of genius, was at this time evinced by the publication, almost simultaneously with the elaborate report on the Florida explorations, of another important outcome of his studies, the volume entitled "The Geographical and Geological Distribution of Animals." This work, which was published in the United States and in England as one of the volumes of the International Scientific Series, presents in a new

light and in logical succession the salient facts which connect the present and past distribution of animal life on our globe and thus a general review of the succession and relation of its various species. This production is in some respects quite unique and retains its place as a standard work on zoögeography.

In the following year, 1888, Heilprin published his book on "The Animal Life of Our Seashore," a popular and most attractive presentation of that interesting subject, and in the same year appeared his work on "The Geological Evidences of Evolution," an amplification of a series of lectures on this topic at the Academy of Natural Sciences. During that year also Professor Heilprin led a class of students of the Academy to the Bermuda Islands to study anew the nature of their coral reefs and singular hill formations and to more closely investigate their animal forms. The results of this journey were published in 1889 in a volume entitled "The Bermuda Islands: a Contribution to the Physical History and Zoölogy of the Somers Archipelago."

The next year, 1890, saw another of Heilprin's important books issue from the press. This was his "Principles of Geology," which forms the seventh volume of the Iconographic Encyclopædia. This book, as its title indicates, is an elucidation of the subject by means of pictures, in this case chiefly photographic reproductions direct from nature. In this regard the author states in his preface that "This work, it is believed, is the first of its kind to make extensive use of what may be called a natural method of illustration." He further observes that "the facts of nature should as far as practicable be represented in a truthful manner and not in a way that compels the mind to accept incorrect ideas. Apart from the benefits derived from correct interpretation, it can fairly be urged as a further advantage of photographic illustration, that it is apt to elicit a primary interest in the subject that is rarely developed by a diagram or even by a diagram and accompanying text." These statements indicate how completely, as well as quickly, Heilprin appreciated the possibilities of the then yet new art of half-tone photo-engraving, which has since then become the most extensively applied of all the graphic arts. The work was designed, as noted by the author, to meet the wants of the general reader without subjecting him to a study of the minute details which encumber most text books and it exemplifies in a high degree that admirable combination of vivid

elucidation and scientific exactness which is so marked a characteristic of Heilprin's writings.

In that year, 1890, Heilprin undertook an exploration of the Mexican Plateau to determine the true nature of that remarkable formation. His investigations disclosed the fact that this vast and lofty plateau is not the result of an upheaval of the earth's crust but has been produced by the accumulation, through ages of time, of material ejected by volcanos, evidences of whose activity are still afforded by the towering peaks of Orizaba, Popocatapetl and other extinct or inactive volcanos which fringe the edge of the elevated plain. Another interesting fact determined in the course of this exploration is the relative height of the two mountains named above, his ascents and accurate measurements of three of the highest peaks having determined the fact that Orizaba and not Popocatapetl was the highest point in Mexico. These studies were continued by Professor Heilprin during his visit to Mexico in 1906 and formed the subject of a volume which he had in preparation at the time of his death.

The new acquisitions of knowledge gained through his expeditions to Florida, the Bermudas and Mexico, led Heilprin to the idea of making the Philadelphia Academy of Natural Sciences a focus of scientific explorations. To this end he entered with zeal into the plan for Arctic exploration projected by Lieutenant Robert E. Peary, of the United States Navy, and promoted it to a successful issue. Heilprin's part in that enterprise cannot be better or more succinctly stated than by a quotation from Commander Peary's letter to the family of the Professor on the occasion of his death. He says: "My own obligations to and regard for him are particularly great. To him, more than to any one else, is due the activity of this country in Arctic and Antarctic work during the past fifteen years; for it was his interest and belief in my first project for Arctic work presented to the Philadelphia Academy of Natural Sciences in 1891, that led to the adoption of that plan by that organization, and the consequent awakening of interest in Polar matters in the years since then."

The history of these later Polar explorations is still in the making. One of its most dramatic episodes, and one that has no parallel except the finding of Livingstone by Stanley in the heart of Africa, was the meeting of Professor Heilprin and Lieutenant Peary, in 1892, in the midst of the bleak expanse of frozen

snow on the lofty surface of the Greenland ice-cap. Heilprin had accompanied Peary to Greenland at the outset of the latter's polar journey the year before and this meeting on the ice-cap was the culminating moment of the Peary Relief Expedition which Heilprin organized and led to its successful termination. The story of that expedition is contained in one of Professor Heilprin's most interesting books, "The Arctic Problem," published in 1893. In this work Heilprin, as usual with him, weaves his scientific data with entertaining narrative into the fabric of an instructive discourse, the volume being furthermore uniquely illustrated with colored plates and reproductions from photographs made by himself.

The exigencies of this relief expedition and the work entailed upon him in connection with the organization of the International Geological Congress, which met in Philadelphia in the fall of 1892, led Heilprin in the spring of that year to resign his curatorship at the Academy, thereafter to devote himself more completely to his literary work and to various projects of exploration. In 1893 he inaugurated the publication of a monthly magazine devoted to geographic science and entitled "Around the World," which was continued during that and the following year and became the prototype of the "Geographical Magazine," published by the National Geographical Society. Of this latter publication Heilprin was from the first one of the editors as he was also a member of the Society's Board of Managers. In 1896 the Geographical Society of Philadelphia, in the organization of which, in 1891, Heilprin had taken a leading part, and of which he had been President during the first four years of its existence, again elected him to its presidency and subsequently, in 1902-3, he again served in that capacity. In the summer of 1896 he made a journey to the Atlas Mountains of Algeria and Morocco to investigate a much discussed theory of a former glaciation of that region. His research resulted in removing all doubt on this subject, no trace of any glacial phenomena, either of a recent or early period, being found anywhere in the mountains. In that year also appeared his admirable text book, "The Earth and Its Story," a work which has met with great favor in educational circles.

His next explorations were made in the Klondike region and in Alaska. There he spent the summer season of the years 1898 and '99, his journey in the latter year extending from the Klon-

dike westward to Cape Nome. These expeditions were devoted to a scientific study of the auriferous deposits on the Yukon and of the gold bearing sands of the seashore north of Bering Strait, and formed the topic of a volume entitled "Alaska and the Klondike," which appeared in 1899.

After some months spent in Europe in 1900, Professor Heilprin, in conjunction with his brother Louis, undertook the arduous and exacting task of re-editing and reconstructing Lippincott's Gazetteer of the World. This work was begun in 1901 and completed in 1905, but was interrupted on his part by the exigencies of his several journeys to Martinique in 1902 and the following year and by the preparation of his books on the Pelée catastrophe. In 1903 he was called by Yale University to direct the department of Physical Geography in the Sheffield Scientific School. His work in that direction was greatly appreciated and was successfully continued to the last.

In 1903 Professor Heilprin was made the recipient of a gold medal by the Geographical Society of Philadelphia in recognition of his eminent attainments in geographical research, and in April, 1905, the great appreciation by the French scientific world of his signal services in the investigation of the volcanic phenomena in Martinique found expression in his having conferred upon him the high honor of appointment as Officier d'Acadmie.

In the spring of 1906 he made a journey into the interior of British Guiana to study the nature of the great equatorial forests of that region, his brief report of which as "An Impression of the Guiana Wilduerness" appeared in the *National Geographical Magazine* for last June, only a month before the author's death. It was during that journey that he contracted the tropical fever which, through intermittent recurrence, gradually sapped his strength and paved the way for an acute attack of endocarditis, which eventually carried him to his untimely grave.

Besides his official connection with the National Geographical Society and with the Geographical Society of Philadelphia, already adverted to, Professor Heilprin was a member of the American Philosophical Society, of the Society of American Naturalists and of the Franklin Institute; President of the American Geological Society from 1891 to '98; a fellow of the American Association for the Advancement of Science, Vice-President of the American Alpine Club, President of the Association of

American Geographers, and a fellow of the Royal Geographical Society of Great Britain. As official representative of several of these bodies, he was a delegate to the International Geological Congress of 1906 in the city of Mexico.

As a recreation from his multifarious labors Heilprin cultivated his taste for painting and music. Several of his pictures have found places in exhibitions in this city and elsewhere, and he left behind him a series of admirable paintings in which several aspects of the Pelée eruption are vividly portrayed.

This sketch of Heilprin's inspiring career would be incomplete without a notice of his activity as a mechanician and inventor. In January, 1882, he was granted a patent on his invention for mechanically turning leaves of music at the piano, the device being also applicable for other similar uses, and in April, 1896, he was granted a patent on a ventilating car window which became the subject of investigation by the Committee on Science and the Arts of the Franklin Institute and was awarded the Edward Longstreth medal of merit in 1897. The working of these inventions he turned over to other hands.

Heilprin's character and the esteem in which he was held by all who were privileged to know him can well be summarized by another quotation from Commander Peary's recent letter, already referred to. He says:

"I have always found him ready, loyal, and superlatively able. When I named one of the greatest of Greenland glaciers and later one of the most northerly lands in the world after him, it was no perfunctory action, but a tribute of the deepest regard and friendship."

I have traced in but brief outlines this story of a most strenuous life, and have but inadequately pictured its restless activity. It was a life informed by a rare intelligence and enlightened by a brilliant intellectuality; a spirit inspired by that lofty altruism which seeks the improvement of mankind through widening our scope of knowledge and deepening our insight into the conditions of existence.

Angelo Heilprin lived but 54 years, yet within that shortened span he accomplished a work of such large moment as would well suffice the compass of the longest lifetime, a work which remains of permanent import to the world and which stands recorded in every library of science, in every language of civilization, in every quarter of the globe.

The Parker Steam Generator.

(*Being the report of the Franklin Institute, through its Committee on Science and the Arts, on the invention of John C. Parker. (Sub-Committee:* Francis Head, Chairman; J. M. Emanuel, Thomas P. Conard, Charles Day.)

(No. 2164).

The Franklin Institute acting through its Committee on Science and the Arts, investigating the merits of "The Steam Generator," invented by John C. Parker, of Philadelphia, reports as follows:—

This steam generator is a water-tube boiler, which at first glance resembles the Babcock and Wilcox type, but which on closer examination will be seen to possess distinguishing features which involve a new principle in the art of steam making. Briefly stated this may be termed the counter-current principle.

The aim is to avoid re-circulation of the water by so proportioning the length and capacity of the tube that complete evaporation is secured in one passage. In practice this is not entirely the case, and there is sufficient moisture in the tubes to prevent their overheating. The water enters the tubes where they are in contact with the coldest gases and travels toward the hottest gases, finally passing over the fire, by which time the water has largely turned into steam. By this arrangement there is always a wide difference of temperature between the water or the steam in the inside of the tube and the gases on the outside, which gives the most favorable conditions for heat transference.

Figure 1 shows in a diagramatic manner a boiler with the assumed temperatures marked in various places. At the top there is a dry steam chamber, a water chamber beneath it, a tubular passage extending downward from the water chamber, the lower end of which is connected to the dry steam chamber by a direct upcast passage. An opening between the chambers, controlled by a non-return valve, completes the circuit and equalizes the pressure. This valve prevents the water from lifting, due to a sudden heavy demand for steam, and a by-pass from the top of the water chamber prevents excessive differences of pressure during such periods.

A non-return valve at the entrance of the tubes prevents a reversal of the flow. In operation the water is fed into the lower chamber, filling the tubes, and seeks its level in the upcast. When heat is applied, the water in the upcast is soon driven out by the expansion of the steam. The result is that more water comes down to regain its level in the upcast and so the action becomes continuous and automatic.

The head which produces the flow is the vertical distance from the surface of the solid water in the lower chamber to the mixture of steam and water in the tube, and to secure this rate of flow is a matter of proportioning the length of tube and rate of combustion and is largely a question of correct design.

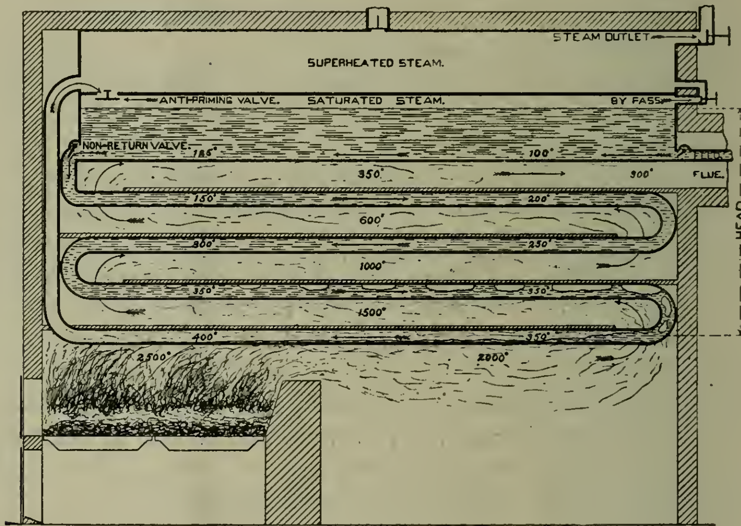

Fig. 1

Another claim of importance is the self-cleaning property of the boiler. This is accomplished by the rapid circulation through the tubes of a more or less solid body of water, whenever a drop in pressure occurs in the upper drum. This has the effect of removing whatever scale is formed and depositing it in the upper drums, where it is readily removed. This is quite successful in practice. Besides this, the boilers give fairly dry steam and have a flexible system of construction, avoiding any strains due to unequal heating.

Another feature of merit is the special form of hand-hole

cover on the box into which the tubes are expanded (shown in figure 2.) These are put in through the tube hole, and have a ground joint. On test they have remained tight under 1800 pounds pressure, at which pressure the tubes start to leak. This is three times the pressure which the ordinary cap, which was tested at the same time, stood.

A very interesting model, which is shown in figure 3, was exhibited in operation to the committee. It consists of one element ¾-inch in diameter by 25 feet long, including 24 tubes, glass upcast and 26 bends. The three tubes next to the door are glass

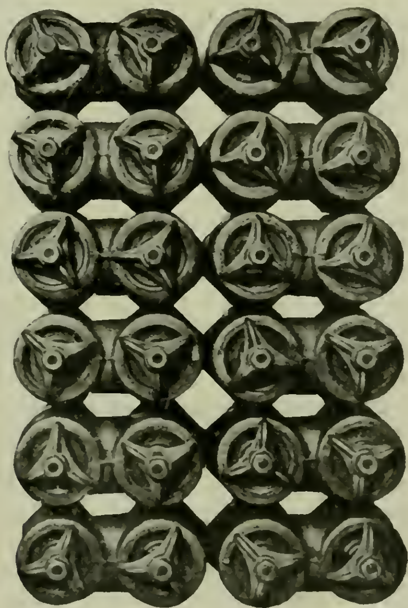

Fig. 2

and held in stuffing boxes, asbestos covered. The lowest stands the direct impingement of the flames with only steam flowing through it. There were six kerosene burners giving an intense blue flame, forced by air pressure, and the boiler carried thirty pounds of steam.

The first boiler of any size was built at Chester, Pa., and was rated at 175 H. P. A full description of this boiler and an account of tests by Prof. Spangler were given in a paper read before the Engineers' Club of Philadelphia, by Henry G. Morris, on April 6, 1901. This boiler has been in service since April 11,

1900, and we make the following extract from Mr. Morris' paper:—

"The lower drum is suspended in steel framework and supports the upper one on flanged necks. The front neck is merely a saddle with no openings into the drums, and is fastened only to the lower drum to allow for expansion of the drum independently. The rear neck, which forms the drain passage, is of steel, with the opening into the water drum brass-bushed, and is controlled by a conical drop valve. The by-pass connecting the drums at the front end has an offset (not shown) to allow for expansion. The drums are slightly inclined downward toward the rear for drainage and to prevent the sediment from going into the tubes a second time. The sediment settles at the rear end of the water drum, whence it is blown out.

"There are eight elements of 3-inch tubes, each having fourteen tubes 18 feet long and one tube 19 feet 6 inches long which connects with the upcast at the rear. The second and fifth rows of tubes are raised to provide access, but this has been found unnecessary. There are three rows of baffles, owing to the flue being at the front. The fire-brick air passages in the combustion chamber did not prove lasting, and were removed.

"This boiler works at 100 pounds pressure and supplies four steam hammers, several engines, and also heats some of the shops. It has 1760 square feet of heating surface, 36 square feet of grate surface, and is rated at 175 horse-power. It has been run up to 265 horse-power.

"Professor Spangler has made six tests of this boiler under normal working conditions. The equivalent water evaporated per pound of combustible from and at 212° F. was as follows: April 18th, 12.54 pounds; 19th, 11.65 pounds; 20th, 11.70 pounds; 21st, 11.81 pounds; 23d, 12.39 pounds; 24th, 11.05 pounds. The return tubular boiler alongside was tested and the result was 10.97 pounds under the same conditions.

"The first annual inspection of the boiler took place on March 31st. The inspection was made by Mr. J. T. Fennell for the Maryland Casualty Company, and a personal inspection was made by Mr. J. M. Lukens, Chief of the Bureau of Boiler Inspection for Philadelphia, accompanied by an assistant. The upper tubes were found perfectly clean, and some thin scale, which appeared to be peeling off, was observed in the bottom row. Mr. Fennell states that the tubes are in the same condition as he found them in his last inspection on December 9, 1900. The scale appears to peel off as fast as it forms, and is carried up and deposited in the drums."

The next boiler built was rated at 400 H. P., and was for the Philadelphia Rapid Transit Co., and was put in service July 26, 1902. This was placed among a row of water-tube boilers of the Babcock and Wilcox type, and was accepted after competitive trials had been made. An account of these tests was published in the *Engineering News* of November 27, 1902, from which the following is extracted:—

TABLE SHOWING RESULTS OF TESTS OF A BABCOCK & WILCOX AND A PARKER STEAM BOILER AT THE POWER HOUSE OF THE PHILADELPHIA RAPID TRANSIT CO., 13TH AND MT. VERNON, STS., PHILADELPHIA.

Items.	Test— No. 1, Sept. 1. B. & W.	Parker.	No. 2; Sept. 2. B. & W.	Parker.	No. 3; Sept. 17-18. B. & W.	Parker.	No. 1; Sept. 25-26. B. & W.	Parker.	No. 5; Sept. 30-Oct. 1. B. & W.	Parker.	No. 6; Oct. 16-17. B. & W.	Parker.
Duration of test, hours and minutes	6.49	6:30	12	12	24	24	24	24	24	24	24	24
Average steam pressure by gage (corrected), lbs.	142.15	142.15	140.8	140.8	143	143	142.14	142.14	142.8	142.8	142.0	142.0
" draft in flue, ins. of water	.76	.16	.658	.675	.77	.77	5	.75	.76	.76	.75	.75
" draft above grates, ins. of water	.544	.464	.533	.408	.62	.50	.60	.50	.60	.52	.59	.50
" temperatures of escaping gases	614.0	410.5	509.9	414.5	536.5	442.8	576	448	575	443	556	448
" temperatures of feed water	80.4	80.4	81.65	81.65	71.0	71.0	72	72	68	68	61	61
Total coal consumed, lbs.	8,306	6,621	14,190	14,775	36,000	37,000	34,000	35,250	36,500	34,500	31,303	35,058
Moisture in coal, lbs.	Dry.	Dry.	Dry.	Dry.	4%	4%	4.5%	4.5%	4%	4%	3.5%	3.5%
Total dry coal, lbs.	8,306	6,621	14,190	14,775	34,560	35,552	32,470	33,664	35,040	33,120	30,207	33,831
Refuse in coal, lbs.	11.7%	11.7%	12%	12%	13%	13%	13.3%	13.3%	13.3%	13.3%	13.3%	13.3%
Total combustible, lbs.	7,334	5,846	12,487	13,002	30,067	30,930	28,152	29,187	30,374	28,715	26,190	29,331
Dry coal per hour, lbs.	1,218.5	1,018.6	1,182.5	1,231.0	1,440.0	1,460.0	1,353.0	1,402.67	1,460.0	1,380.0	1,258.6	1,409.6
Steam, percentage of moisture	40%	22%	62%	.33%	.40%	.26%	.48%	.25%	.39%	.24%	.59%	.28%
Water from separator per hour	....	....	....	....	....	....	36.04	24.1	35.74	30.9	37.78	28.0
Total water pumped into boiler, lbs.	62,721	60,936	111,282	125,369	280,893	312,811	254,138	293,763	283,300	281,563	231,990	281,659
Equivalent evaporation, from and at 212° F.	71,261	72,148	131,647	148,311	335,386	373,496	303,187	350,459	339,110	337,031	279,316	339,117
Equivalent evaporation from and at 212° F., per hour	10,894	11,099	10,970	12,359	13,974	15,562	12,633	14,602	14,130	14,043	11,638	14,129
Economic results: Water actually evaporated per lb. of dry coal	[illegible]55	9.20	7.84	8.48	8.12	8.79	7.83	8.73	8.08	8.50	7.68	8.32
Equivalent water evaporated per lb. of dry coal from and at 212° F.	8.94	10.89	9.28	10.04	9.70	10.50	9.34	10.41	9.67	10.18	9.25	10.02
Equivalent water evaporated per lb. of combustible, from and at 212° F.	10.12	12.34	10.54	11.41	11.15	12.07	10.77	12.01	11.16	11.74	10.66	11.56
Percentage of gain	....	21.8%	....	8.2%	....	8.25%	....	11.5%	.....	5.2%	......	8.4%
Dry coal per sq. ft. of grate per hour	18.3	15.3	17.78	18.51	21.65	22.25	20.34	21.09	21.95	20.75	18.93	21.20
Water evaporated, from and at 212° F., per sq. ft. of heating surface, per hour	2.67	2.65	2.69	2.94	3.43	3.71	3.10	3.48	3.46	3.35	2.86	3.37
Horse-power (34.5 lbs. water from and at 212° F. pr hr.)	315.77	321.73	318.0	358.0	405.0	451.0	366.0	423.0	109.5	407.0	337.34	409.55
Heating surface per HP.	12.90	13.03	12.81	11.71	10.06	9.29	11.13	9.91	9.95	10.30	12.08	10.21
Horse-power per sq. ft. of grate	4.75	4.84	4.78	5.38	6.09	6.78	5.50	6.36	6.16	6.12	5.07	6.16

"In accordance with your request for information in regard to the contract tests of our boiler conducted by the Rapid Transit Co., in competition with one of their Babcock & Wilcox boilers, we forward you data, drawings, photos and samples of scale.

"We guaranteed that our boiler would evaporate more water under equal conditions of operations than their boiler. (2) That our boiler would not scale as rapidly as theirs. (3) That our boiler would wash out its own tubes automatically and constantly while in operation. (4) That our steam would be dryer, and that it would be impossible to cause it to prime. (5) That our tubes would not burn or blister. (6) That our hand hole joints could be made quicker and could be turned to stop a leak under pressure with safety.

"We agreed that the Traction Co. should conduct the tests and specified the following conditions:

"1. Both boilers to be put in perfect condition.

"2. To be operated simultaneously and under equal conditons.

"3. A separator and calorimeter to be connected to each steam pipe to intercept and measure the entrained water.

"4. Feed water to be unpurified city water from open heater or direct from mains.

"5. Both boilers to be operated at maximum power for 30 days of 24 hours each, without stopping; any leaks or other injury to be repaired and charged against boiler together with time lost.

"6. On the last day of trial the coal and water shall be weighed for 24 consecutive hours and the moisture in the steam deducted from the apparent evaporation, which shall then be computed for the full 30 days.

"7. Both boilers shall then be opened, and whatever repairs or cleaning are necessary shall be done and charged against each respectively.

"8. The net difference, if any in favor of the Parker steam generator, multiplied by 24, shall be deemed to represent the saving for two years, and the amount in dollars and cents, not exceeding * * * shall be due the Parker Engine Co. as a bonus in addition to the contract price.

"The Parker boiler was started on July 26, but owing to the coal strike the Traction Co were not able to get their boiler in condition before Sept. 1, when the test was started.

"The tests of Sept. 1st, 2nd and 30th were conducted by Mr. Francis Head, assistant engineer of the company, in person, while in the others some of his assistants were present.

"No attempt was made to get extraordinary results. The regular firemen were used and one man fired both boilers through his full eight-hour shift. The only instructions given were to treat both boilers exactly alike and whenever anything was done to one fire the other was to be immediately treated likewise. No one meddled with the fire-doors but the fireman himself. The fires were cleaned at the end of each shift by the regular gang who took the usual time.

"The coal used was bituminous, run of mine, stated by the company chemist to contain 14,100 B. T. U. per pound. It was of a caking variety and had to be worked a good deal, and a great amount of clinker was

taken out at each cleaning, a good deal of time being lost in this respect and in getting the fire burning properly afterward. The coal was weighed on the same scale in the same barrow, which held 125 lbs. net, not full enough to spill in wheeling. The floor was swept up and four barrows delivered to each boiler alternately, making 500 lbs. net delivered at a time.

"To start and stop a test 500 lbs. of coal was put on the floor and the fire cleaned and the time and water taken when the fire was covered. The time of weighing the coal was taken but not the firing time.

"All openings to the boilers through which leakage might occur were blanked and the feed pumps set over their own tanks so that the leakage from them would not be lost. The water was weighed in tanks on scales resting on the suction tanks and the time of weighing and time of passing a mark in the suction tank was taken. The scales were found to agree by weighing water in one and then running it into the other.

"The boilers are connected to the same flue and steam main and each has an Eynon & Evans steam jet blower in the ash pit, but this was only used in the test of Oct. 16. This attempt to get over 500 H.P. out of the boilers by use of the blowers resulted in showing that the blowers hurt the soft-coal fire rather than helped it.

"The Sept. 1 test shows the unreliability of short test, since the Parker boiler showed an impossible advantage. On the other hand the Parker boiler got the worst of it in the Sept. 30 test, owing to a badly-clinkered grate. All the firemen complained about it and did not seem to be able to handle the fire in the usual way. Comparing this test with that of Sept 17th, it will be seen that the Babcock & Wilcox used more coal, while the Parker fell off 2,500 lbs. The firemen were unable to dislodge the clinker during the test without keeping the fire doors open for an excessive period, so the test was made of a bad job.

"On the 20th day of the 30-day run a defective expanded joint in the Parker boiler gave out and the boiler had to be shut down. The tube end had not been run past the shoulder in the box. The tube was pulled back into the box by running a length of pipe through it and screwing up on a flange at each end

"On the 20th day of the run a tube was found blistered in the Babcock & Wilcox boiler, and it had to be shut down and a new tube put in. The clinker was chipped off the grate and this was the cause of the good showing in the Sept. 30 test. At the end of this test it was discovered that two more tubes were blistered in the Babcock & Wilcox boiler and had been leaking during the test.

"It was assumed that the leakage did not measurably swell the apparent evaporation of the boiler since it had shown about the same results in the test of Sept. 17.

"The Parker boiler was shut down on Oct. 9 and opened up in the presence of City Inspector Madden and representatives from the Baldwin Locomotive Works, the United Gas Improvement Co., the Penna. R. R. Co., the Edison Illuminating Companies and Mr. Francis Head for the Traction Co. Mr. Madden pronounced the tubes clean, although it was evident that scale had been formed in the bottom row as scattering patches

of it could be seen and 186 lbs. of it in small pieces was found in the front ends of the drums. About 4 ins. deep of mud was found in the water drums, while the steam drum was clean except for 33 lbs. of larger pieces of clean scale retained at the front end by the screen.

"The valves in the top boxes of each element were found clean and in perfect working condition.

"The scale appears to form entirely in the bottom tubes, and as soon as it attains any body peels off and is swept out of the tubes and thrown up into the drums by the force of the flow, exactly the same as in the Parker boiler at the Roach shipyard, Chester, Pa., which has been running now for two years and a half without any cleaning of the tubes except by the boiler itself. The mud is found to settle toward the middle of the water drums and an angle has been placed over the drum blow-offs so that the mud is now blown out very efficiently.

"The price of coal at the time of the tests being abnormal, $3 per ton was agreed upon as a fair basis for computation for bituminous coal at the fire doors. On this basis the saving shown by the Parker boiler over the Babcock & Wilcox computed according to contract was as follows: Sept. 1, $6,149; Sept. 2, $2,224; Sept. 17, $2,863; Sept. 25, $3,765; Sept. 30, $1,829; Oct. 16, $2,534.

"It was understood, of course, that to get this saving the boiler must be run at full power for the full time.

"As the lowest figures were far above the limit of the bonus and all the other claims were conceded, the company paid the Parker Engine Co. the full amount of the bonus on Oct. 10.

"The test of Oct. 16 was run to see what the boilers would stand without injury, but the blowers failed to add to the power, and this test fell far short of the results on Sept. 17, when the average for one of the eight-hour shifts ran up to 470 H.P. on the Parker boiler.

"The accompanying table gives the results of the tests. The heating surface of the two boilers tested was as follows:

	B. &. W.	Parker.
Heating surface in tubes, sq. ft.	3.761	3.985
Heating surface in drums, sq. ft.	314	209
Heating surface, total sq. ft.	4.075	4.194
Grate surface, sq. ft.	66.5	66.5

"The samples of scale taken from the Parker boiler, submitted to us with the above letter, are all about 1-16-in. in thickness. Why the scale should flake off in this boiler after reaching this thickness and not continue to accumulate, as happens in other types of water-tube boilers, is a difficult question to answer. Apparently the only reason that can be found is the velocity of circulation through the lower tubes, which is very much in excess of that in any other design of water-tube boiler which we now recall."

This boiler is in use at the present time, and another competitive test made during the spring of 1903 showed over 5 per cent.

in favor of the Parker boiler, even after the Babcock and Wilcox had been thoroughly cleaned, while the "Parker" had never had its tubes brushed out.

During the time this boiler has been in service, 18 months, there have been but three tubes replaced, one of which was cut in being expanded into the boxes and one other had a slight crack caused by work done on it previous to this period of test. Four tubes have pulled out of their boxes, and as three of these occurred in one element, it was found to be due to a defective check valve.

This boiler is at the 13th and Mt. Vernon Sts., power station, and was built out of a three-drum boiler of the Babcock and Wilcox type, the middle drum of which was raised to serve as the steam chamber, the water level being maintained in the other two. Curved tubes were put in the bottom row, so as to get the upcasts up separately to the steam drum at the front end. In the later designs, straight tubes are used. This boiler has been examined while in operation and while laid off for inspection by members of the sub-committee and many prominent engineers, who have satisfied themselves that the tubes were free from scale, which appeared to collect in the drums, from which it could be shoveled out together with the mud which had settled there.

The satisfaction given by this boiler and its advantages in economy and in keeping free from scale have caused the Philadelphia Rapid Transit Co. to have six more built, with 6500 sq. ft. of heating surface each. Some of these are now in operation. These boilers have two 54-inch drums, which are divided by a horizontal diaphragm, forming the steam and water drums in one shell. All the tubes are straight and quite accessible, and special facilities are provided for blowing off the flue dust from the tubes by steam jets, which are built into the setting. Two similar boilers, with 8730 sq. ft. of heating surface each, have been put in operation at John B. Stetson's factory, Philadelphia. There are also three small boilers in use, one of 100 H. P. in Chester, Pa., and one of 200 H. P. in Philadelphia, and one in Michigan.

Figure 4 is a longitudinal section of the boiler as now built. Figure 5 shows how the front junction boxes may be separated to replace a tube. The boxes above the tube to be replaced are lifted five or six inches.

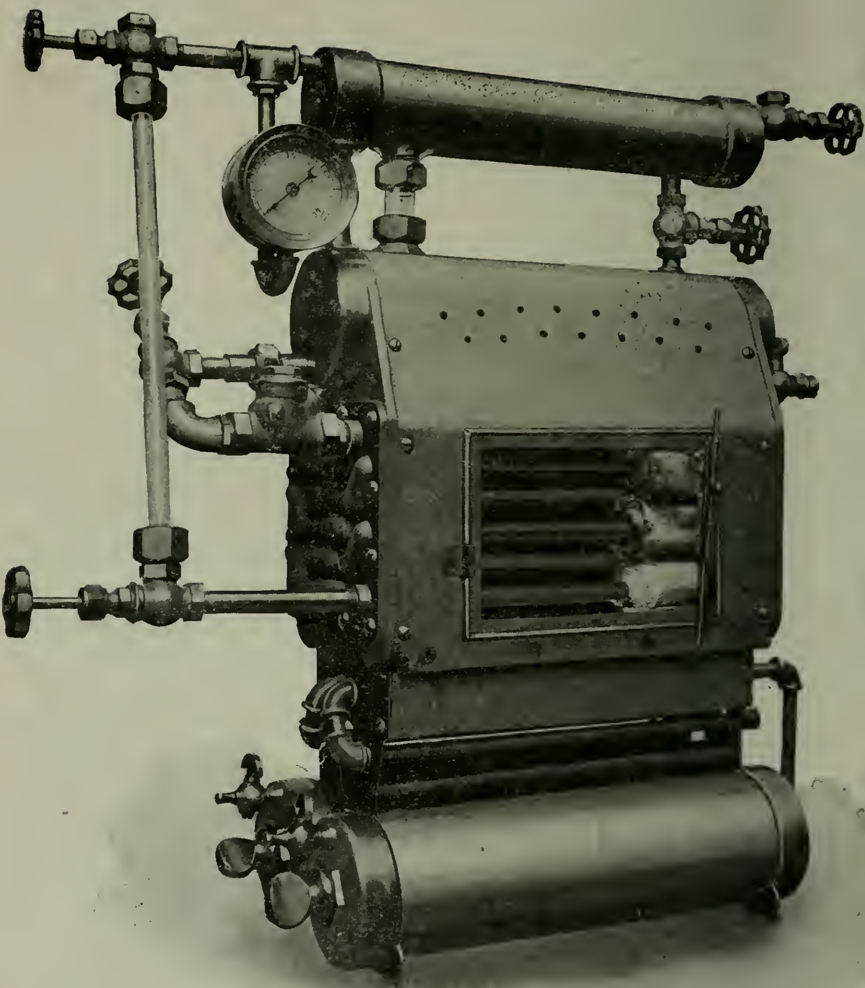

Fig. 3

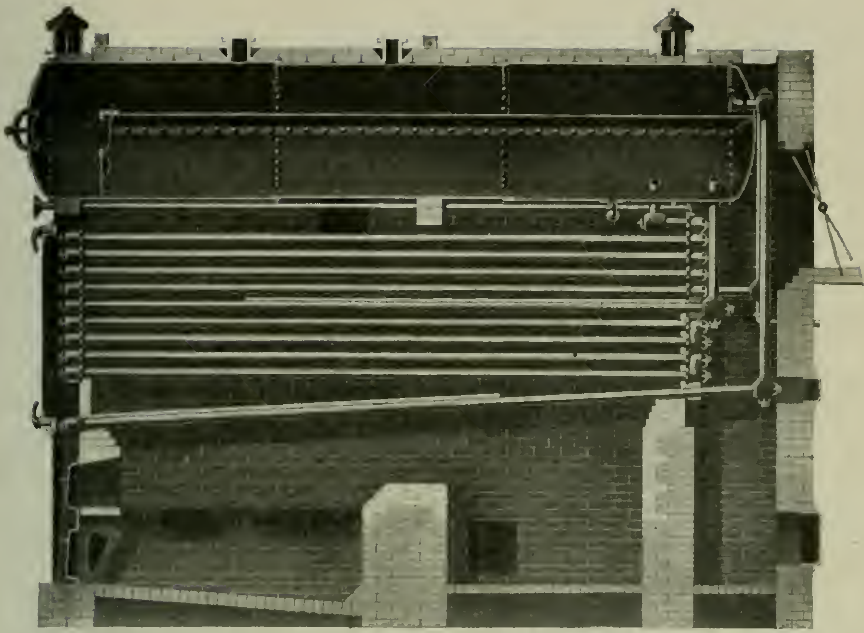

Fig. 4

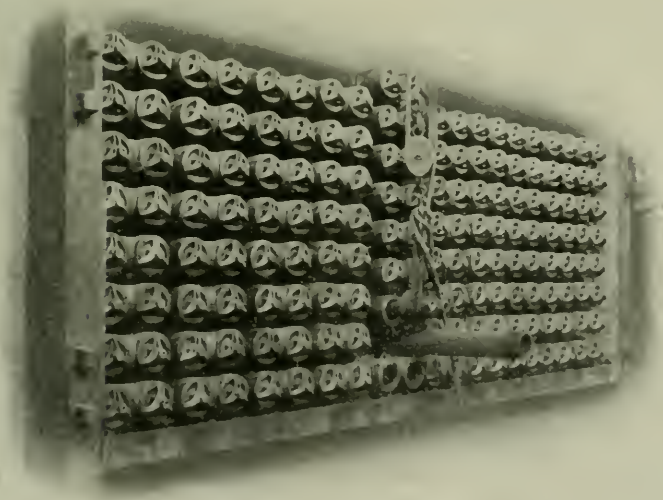

Fig. 5

In the Parker boiler the economizer principle has been applied in a water-tube form of construction, which embodies all the advantages of this well-known type, and to these advantages have been added self-cleaning features not possessed by older types.

The essential features of forced circulation are broadly covered in U. S. Patent No. 608,218, dated August 2, 1898, and in No. 628,606, dated July 11, 1899, which is of less importance, copies of which are appended to this original report.

In conclusion, your committee deems it most remarkable that after the many years in which boilers have been made and in many forms in which they have appeared, each of which presented some novelty of construction or improvement, that there should be room for anything new in this well-worn field.

An examination of the various types, beginning with the plain cylindrical boiler, the return tubular and last the water-tube, will show that, while great strides have been made on the score of safety and economical performance, by decreasing the size of the heated unit and increasing the proportion of heating surface to grate, up to the present there has been no radical change which would allow of the highest thermal efficiency.

In recognition of the invention of an improved water-tube boiler by John C. Parker, and of his additions to our knowledge of the Art of Steam Generation, the Franklin Institute recommends to him the award of the Elliott Cresson Medal.*

Adopted at the stated meeting of the Committee on Science and the Arts, held Wednesday, March 2, 1904.

ATTEST: WM. H. WAHL, *Sec'y.*

A BIG SPRING.

No State in the Union has larger or more numerous springs than Florida. Many of them form good-sized streams from the start, and some of them are navigable. The largest spring in the State, and one of the largest and probably the best known in the United States, is Silver Spring, which is located six miles east of Ocala. This spring forms the source of the Oklawaha River, a tributary of the St. Johns, and steamboats traversing the river enter the spring basin, which has an area of several acres. The water is from 25 to 30 feet deep and is wonderfully clear, appearing absolutely colorless.

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*Since the adoption of the above report about 50,000 H.P. of these boilers have been placed in service. F. H.

(Stated Meeting held Wednesday, September 16, 1907.)

Camden's Artesian Water Supply Is Not Derived from the Delaware River by Infiltration.

By Prof. Oscar C. S. Carter.

The subject of underground water is one that requires knowledge of a special kind. It is not a question that can be worked out in the library or a question that an engineer or chemist can decide offhand. The problem of underground water in all its intricacies is primarily a question for the geologist who has given special study to dynamical and structural geology, or better, to that division of the subject known as stratigraphy. He may be an excellent authority on fossils and know comparatively little about underground water; he may be an authority on topography or an expert mineralogist and lithologist and yet be incapable of giving the simplest advice about the circulation or supply of underground water. A geologist with modern chemical training such as is given by your universities to-day can readily determine whether a water is hard or soft or even if it be unpotable from large excess of organic matter, but these are questions primarily for the chemist, and a complete up-to-date analysis of water in which the percentage of all the constituents, even the most minute, are determined, requires skill and care.

The chances of getting underground water, the probable yield, whether it will be constant, and many other questions that arise; the geologist can often solve if he has made a special study of this subject, but something more is necessary besides this theoretical and technical knowledge and that is a practical knowledge gained by studying the records of artesian wells drilled in different parts of the country as the work progresses. By artesian well records we mean records kept of the depth of well, kind of rocky strata passed through from top to bottom, number of crevices struck and whether they yield water or are dry crevices, height of water in the well, number of gallons yielded per hour, how

much the water drops in the well on pumping several hours or days, &c. It seems wonderful to the layman that a driller when drilling an artesian well 1500 feet deep, or deeper, can tell the number of crevices struck and whether they yield water to the well or are dry, and yet the mystery is not so great when we know that the heavy drill is attached to a long rope which is lifted by the engine; the driller merely turns this occasionally so that the drill makes a round hole. When the drill strikes an underground crevice it drops and the driller feels it. When the sand pump or bucket is put down to clean out the drillings and there are none there, he knows they were washed away and he has struck a stream in a crevice of running water. He knows the depth of rope in the well and how much it dropped when the crevice was struck and hence the width of the crevice. Camden is a city located in New Jersey along the Delaware River opposite Philadelphia. It is the starting point for the railroads that lead to Atlantic City. The water supply since 1853 was drawn from the eastern channel of the Delaware, which flow between Pettys Island and the Jersey shore, but as the Delaware receives the sewage of Philadelphia and the towns above, and the tide rushes up the estuary known as the Delaware Bay and then up the river as far as Trenton the source of supply was finally abandoned owing to the increase of typhoid cases and other forms of sickness. Artesian wells were then looked to as a source of supply and a series of test wells were put down just north of Delair, a small town two or three miles north of Camden, along the Delaware. These wells furnished an excellent supply of potable water. It was then determined to draw the entire supply for the city of Camden from this vicinity. Accordingly about 100 acres of meadow land just north of Delair along the Delaware River between Pensauken Creek and Pochuck Creek were purchased. This land lies between the Camden and Amboy R. R. and the Delaware River. In this tract within a stone's throw of the river during 1897 and 1898 there were put down one hundred and one artesian wells. Eighty-nine of these wells were drilled in the ordinary way and twelve put down by the hydraulic process. Some of the details about the wells are taken from the Annual Report of the State Geologist of New Jersey for 1898 and were collected by Lewis Woolman, to whom much credit is due for his industry in collecting records of New Jersey's underground

water supply. The twelve wells in the southern tract were provided with strainers at the bottom thirty to forty feet in length. They were of galvanized iron pipe provided with $\frac{3}{8}$-inch holes and covered on the outside with brass cloth. The remaining eighty-nine wells had strainers twenty-four feet long with par-

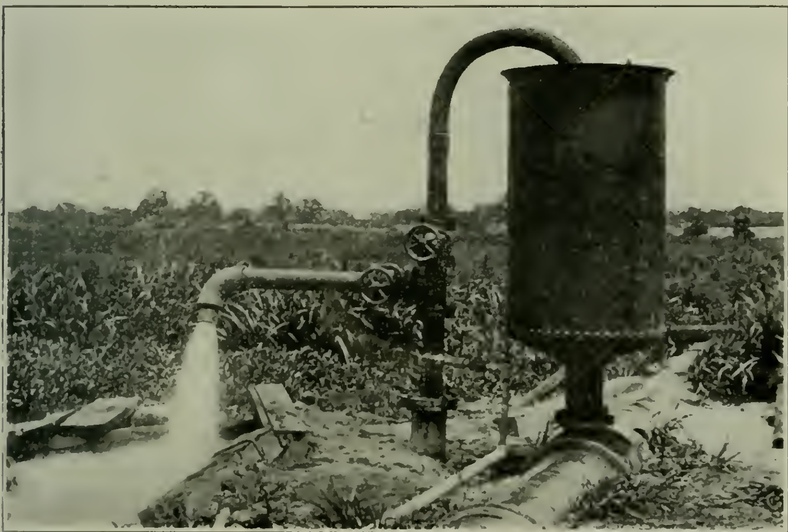
U. S. Geological Survey contour map of a part of New Jersey, showing location of artesian wells between Morris and Delair.

allel slots [illegible] of an inch apart. Reference is made to these strainers because they were afterwards changed. It is understood that these wells are lined with iron pipe which is lowered as the well is drilled and the strainers allow the water to enter at the bottom and prevent the well clogging with sand or clay. The wells

are classified into shallow and deep wells. The shallow ones are from fifty to seventy feet in depth and the deeper ones from ninety to one hundred and twenty-five feet. The author is well aware that some authorities would like to limit the term artesian well to deep wells that flow. But this is not the general acceptation of the term at all among authorities at the present time. Artesian wells are named from the province of Artois in France. Hundreds of artesian wells are put down in this country (United States) every year, some of them from 1000 to 2000 feet in depth and probably not five per cent. of those put down in the Eastern States are flowing wells. The water rises to within ten to thirty feet of the surface and is readily pumped the rest of the way. In the West, flowing artesian wells are more common, and it is no uncommon sight to see an enormous stream feeding an irrigation ditch or forming a small artificial lake where thousands of cattle are watered. Neither is it desirable to restrict the term artesian to very deep wells. Many shallow wells that are drilled in the ordinary way or by the hydraulic process furnish an abundance of water, often more than the deeper wells. The difference between an artesian well and a dug well is so clear that it is not necessary to restrict the term artesian to flowing wells. In order to get a clear conception of New Jersey's artesian wells we must have a general idea of the topography of the State. Most of these wells are in the southern half of the State, known as the coastal plain, a low, flat sand plain which we travel over from Camden to Atlantic City. Northern New Jersey is mountainous. The Kittatinny Mountains, belonging to the Appalachians, extend from Pennsylvania through Northern Jersey. They are steep sided, even crested ranges over 1500 feet above tide with wide valleys between. The next zone south and east of the mountains are the Highlands, a series of block-like masses, not peaks; the elevation is about 1200 feet above tide. The next zone south and east of the Highlands is the Piedmount plain, commonly called plateau. The topography varies; in some places it is low plateaus, in others it is a rocky, rolling country. The elevation is about 800 feet above tide. These zones comprise the northern half of the State, which is mountainous or hilly. There are plenty of rivers and creeks and water power is ample, hence artesian wells are not so necessary in Northern New Jersey. But in Southern Jersey the rivers flow sluggishly along the sandy, coastal

plain. There are few cascades or waterfalls, hence practically no water power for manufactories unless dams are built, and the topography is not favorable for them. The creeks are far apart and small, hence towns, villages and farms often depend wholly on artesian water. Along the coast where the tide ascends the lagoons and tidal estuaries and makes brackish water in the rivers this is especially the case, and Atlantic City, Ocean Grove and in fact all the seaside resorts use artesian water. The so-called coastal plain of the United States begins at Long Branch and extends along the Atlantic coastal and Gulf States to the Rio

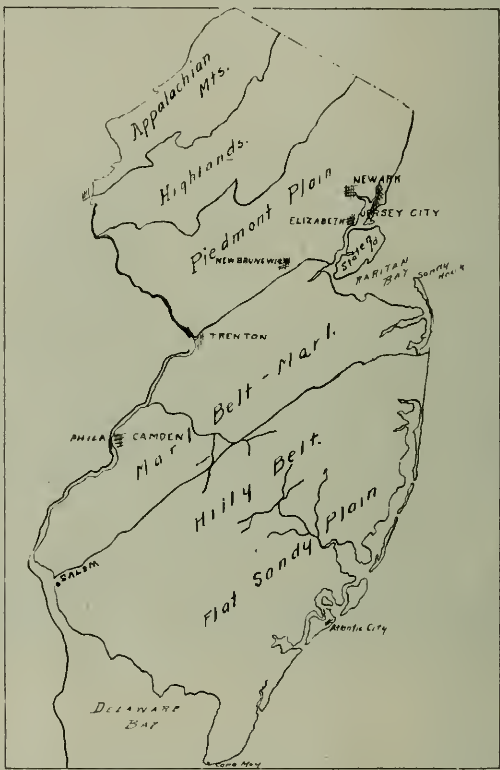
Water Department Report, 1906



New Air Well at Morris.

Grand River in Texas. It is a country of sands, marls and clays and is not rocky in the popular acceptation of the term. The plain varies from sixty to one hundred miles in width. This plain does not end at the beach but continues under water out to sea for from fifty to one hundred miles according to locality. It is known as the submerged coastal plain. The increase in depth is very gradual, in fact the fall is only five or six feet per mile, which would make an almost perfectly level plain to the eye, if the ocean should recede and the land become elevated. In fact

we have to travel 100 miles off Sandy Hook before we reach the 100 fathom line, but when we come to the end of this great submerged continental platform the depths are no longer shallow but abyssal. Now there are three divisions of this coastal plain in Southern Jersey. The marl belt, the hilly belt and the sandy plain. When we leave Camden for Atlantic City we soon enter the marl belt. Marl is a greenish earth made up of shells and

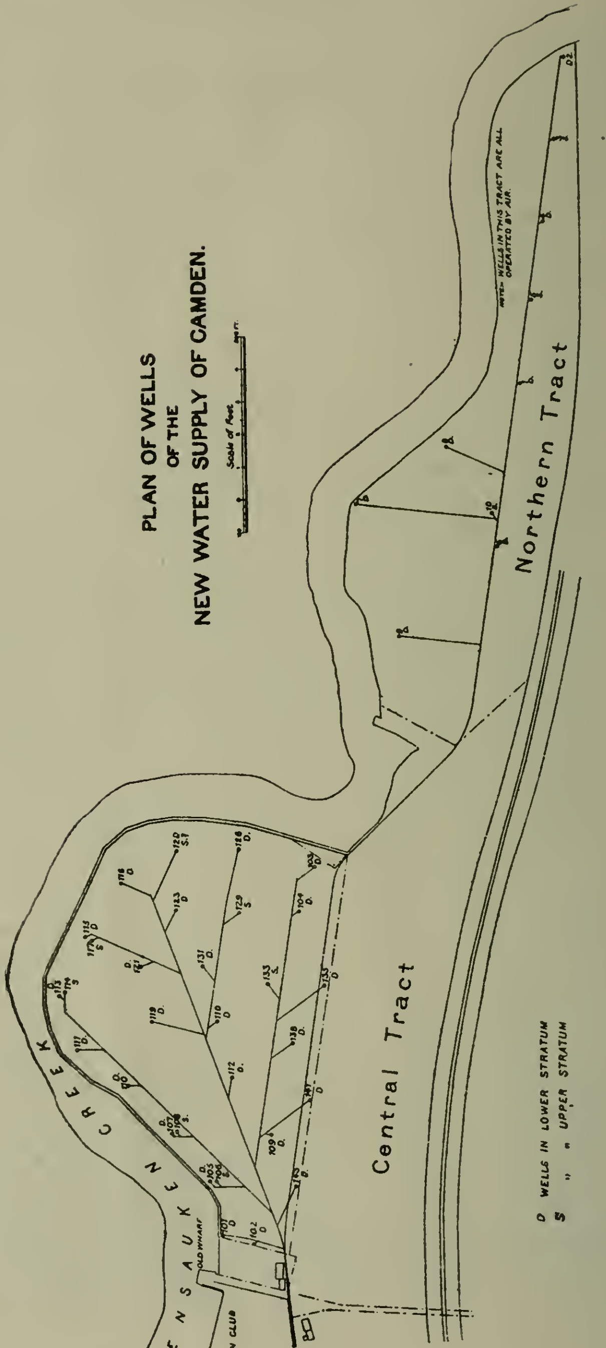


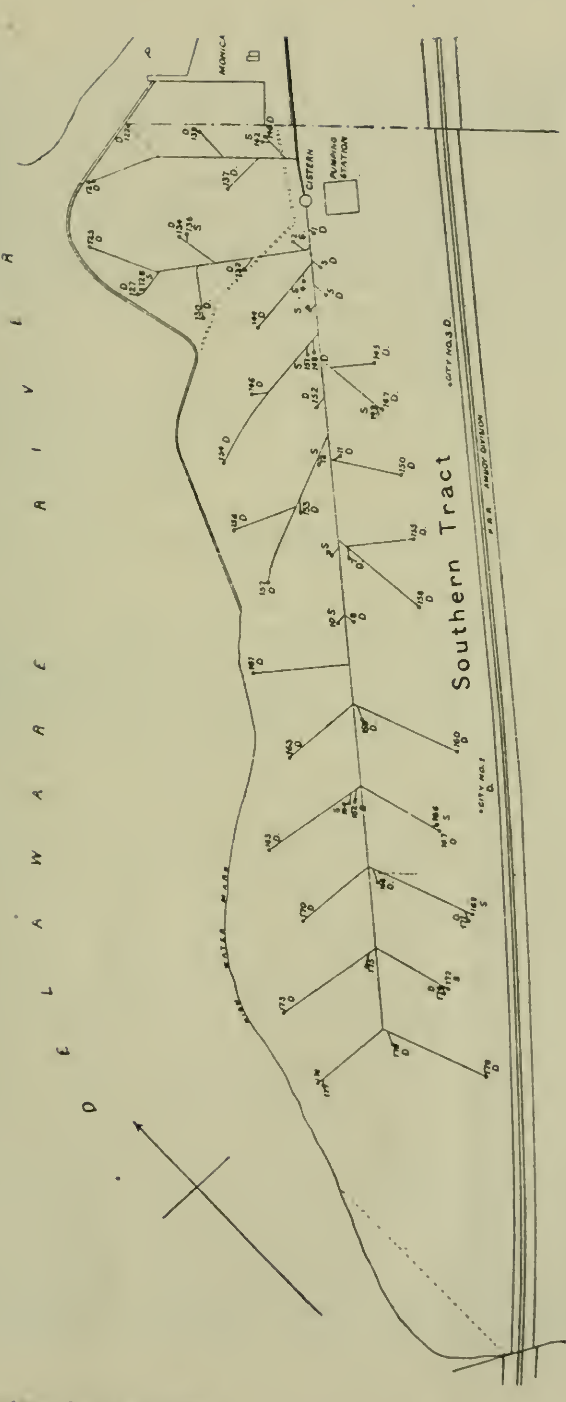
Map of New Jersey, showing the prinbipal topographic divisions of the State.

clay. The lime of the shells makes it a valuable fertilizer for cereals and grasses. There is a little phosphoric acid and potash in green sand marl. The Marl Belts extend from Raritan Bay to Salem on the Delaware River. The belts are from five to fifteen miles wide and vary in thickness from two inches to twenty feet. The beds dip or slope towards the ocean. When we leave the marl belt we come to the hilly belt. These are generally sand

hills of gentle relief and they act as a water shed and separate the streams which flow into the Atlantic Ocean. In the marl and hilly belts we find the best farm land in Southern Jersey. Between the hilly belt and the ocean stretches the long, low and level sandy plain. Here the soil, on account of the sand, is unusually poor and in marked contrast with the other belts; farms are few and far between and the greater part of the plain is covered with unbroken pine forests and a dense undergrowth of high ferns called brake. When we examine the sand we see that it is ocean sand. The gravel beds miles away from the shore, now used for macadamizing, tell an interesting story. They were the beach lines of former ages where the pebbles along the beach had their sharp corners worn off by the action of the waves. Enough has been said about the topography of Southern Jersey to make it plain that the formations were laid down under water; the oyster and other shells in the marl show it, and the old beach lines of pebbles and the fine white beach sand miles inland prove it.

At the end of a certain age of the cretaceous period, known as the Dakota Age, there was a great subsidence of the eastern coast of the United States, and what is now known as the coastal plain, which begins at Long Branch and ends at the Rio Grande in Texas, was submerged under the Atlantic. The southern half of Jersey just described was under water and the waves beat against the ridge of hills known as the Chestnut Hill Ridge just back of Philadelphia. It was during the cretaceous period that the upper, middle and lower marl belts were laid down under water after the subsidence of the coast line. The marl at Mullica Hill and other places is one mass of fossils, containing such well known forms as Exogyra and Gryphœa, both members of the oyster family, also Belemnite casts, a member of the cuttle fish order and the casts of numerous marine snail shells (Gasteropods.) The Philadelphia rocks, which we find at Chestnut Hill, Germantown, Bryn Mawr and along the Schuylkill from Gray's Ferry up beyond Lafayette, are gneisses, mica, schists with belts of igneous rocks here and there. This rocky floor of micaceous rocks extends under Southern Jersey and may even extend under the ocean as far out as the edge of the submerged continental platform. It can readily be seen that this rocky floor formed the bed of the ocean and the clays and marls of the cretaceous period were laid down upon this rocky floor which is


PLAN OF WELLS
OF THE
NEW WATER SUPPLY OF CAMDEN.
Scale of Feet
NOTE:- WELLS IN THIS TRACT ARE ALL OPERATED BY AIR.
Northern Tract
Central Tract
NSAUKEN CREEK
OLD WHARF
N CLUB
D WELLS IN LOWER STRATUM
S " " UPPER STRATUM


D E L A W A R E   R I V E R
Southern Tract
CISTERN
PUMPING STATION
MONICA
CITY NO. 1 D.
P. R. R. AMBOY DIVISION

now buried many feet below the surface. The deep well at Atlantic City (2000 feet deep), which was drilled from the pier in the ocean, did not reach this rocky floor. The beds of clay and sand resting on top of the marls are younger because they were laid down afterward; they vary in age according to position, from the surface Quaternary beds to the deep miocene beds of the Tertiary period. In the following table the youngest beds are on top and the oldest at the bottom:

Quarternary Period:—Sand and gravel.	
Tertiary Period:—Sand and gravel.	
	Age, Manasquan or upper marls.
	" Rancocas middle marls.
Cretaceous Period........................	" Monmouth lower marls.
	" Matawan clay marls.
	" Raritan plastic clay.

The plastic clays of the Raritan rest on the rocky floor. The accompanying ideal section from a paper by N. H. Darton, of the United State Geological Survey, makes clear the position of these beds and the rocky floor which underlies them. It is evident from the section that these beds dip or slope towards the ocean. The second ideal section shows how the rainfall in Southern Jersey filters down through the sand until it meets a bed of clay which is impervious to water. The sand bed confined between two clay beds becomes saturated with water so that when an artesian well is put down to the sand bed, the water rises in the iron pipe and sometimes overflows, providing, of course, the column of water in the sand bed is higher than the well. These general preliminary facts are necessary to a clear comprehension of Southern Jersey's underground water supply. The plan of the wells above Camden is taken from the Annual Report of the State Geologist for 1898, shows the position of the wells in the southern, central and northern tract and shows that they are all near the Delaware River or its tributary, the Pensauken Creek. It shows that they are all connected with lateral pipes which empty into four main pipes, which, in turn, empty into an enormous cistern or underground reservoir known as the receiving well, which is thirty-five feet deep and thirty feet in diameter From this reservoir it is forced to Camden through a 36-inch main over 19,000 feet long and then by a 30-inch main about 13,000 feet long to South Camden, where there is a stand pipe on elevated ground which pipe is 110 feet high and thirty feet in

diameter. The only misleading thing about the drawing showing the plan of the wells are the numbers attached to each well. These are not depths of the wells but are numbers that were given to them in the order that they were put down. It is evident that the wells are put down in the sand along the river. Several years ago at a monthly meeting of Philadelphia geologists Mr. Woolman was explaining the underground water horizon of New Jersey by means of a large colored chart which was exceedingly instructive and useful and had been prepared with great care from many records of artesian wells. The statement was made that Camden artesian water supply at Delair was derived from the Delaware River by the water filtering through the sands. During the discussion the almost unanimous opinion was that Camden's water supply was merely Delaware water that had filtered through the sands. The author dissented from this opinion and at a future meeting presented proofs to support the opposite view.

Section of coastal plain in Southern Jersey, showing relations of artesian wells and water horizous

which is that Camden's water supply does not come from the Delaware but from the higher ground east of the Delaware where it filters down through the sand towards the river valley, and that the composition of the Delaware water is entirely different and that analysis shows them to be totally unlike. Some contend that this is a matter of grave import to Camden, inasmuch as they went to great expense to avoid the Delaware water and that they do not want it even if it filters through the natural sand beds along the river. Of course there is this to be said about it, the conditions are entirely different from those of an artificial filter bed; the artificial beds can be cleaned and they are not used until they are ripe, that is, until a slimy vegetable growth accumulates on the top layer of sand. It is this slimy growth which does the work and filters out the disease bacteria as well as the harmless ones. It is a well known fact that we could not pack even very fine sand close enough to remove germs that it takes a microscope of high power to detect, but when the slimy growth accumulates

the bacteria are destroyed. Whether these thick sand beds between the wells and the river would filter the water thoroughly, providing it might drain towards the wells, is a question that will bear investigation; the author inclines to the view that they would. The people of Camden, however, need give themselves no concern on that score, as the water comes from a different direction, for the following reasons: First, the composition proves them to be entirely different. These analyses were furnished by the City Engineer in 1900; they were made some time previous:

Artesian Water from Test Well.

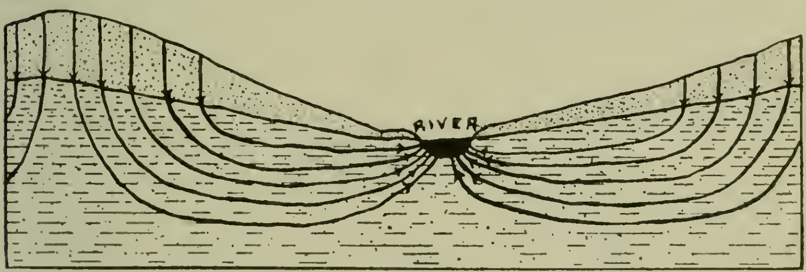
Total solids	30.
Chlorine	8.6
Free ammonia	0.15
Albuminoid ammonia	0.12
Nitrites	None.
Nitrates	2.210
Silica	.827
Iron	.1
Alumina	.298
Lime	.443
Magnesia	.16
Sulphuric acid	.118

Delaware River Water, Taken 150 feet off Fishers Point.

Total solids	110.
Chlorine	5.0
Free ammonia	0.04
Albuminoid ammonia	.10
Nitrites	None.
Nitrates	Trace.
Condition	Slightly turbid.
Color	Slightly yellow.
Odor	Faintly musty.
Reaction	Alkaline.

The first analysis was made by Gilbert Landis; the second by Dr. Henry Leffmann. They are calculated in parts per 1,000,000. The total solids in the artesian water are low, less than one-third of what they are in the Delaware water. The lime and magnesia are particularly low; this makes it a very soft water and explains why no scale forms in the boilers since they have been using artesian water. This was not the case where Delaware water was used, as a scale formed then. The hardness of the artesian water is only 1.78 degrees, which is very much less than even Schuylkill water. This is very unusual, because artesian waters in Pennsylvania are generally harder than river waters. The author has made a study of between thirty and forty wells drilled in Southeastern Pennsylvania and published the records of most of them and their waters are generally harder than river water, particularly the wells drilled in the Triassic sandstone of Bucks and Montgomery counties. Some of these wells yield water twice as hard as Schuylkill water, although much of the hardness disappears after the well has been in use for several months. The second proof that it is not filtered Delaware water is: That not over six weeks elapsed after these wells were started and millions of gallons were pumped for Camden before it was found

that the farmers' wells east of Delair within a mile ran dry. These were the ordinary shallow dug wells. Many farmers were obliged to put down deep artesian wells. Now if Camden's supply merely filtered in from the Delaware, the farmers' wells east of Delair, some of which are on high ground, would not be affected in the slightest. The artesian wells in the northern and central tract extend to Pensauken Creek and even the farmers on the other side of the creek and beyond complained that their dug wells ran dry. These facts clearly prove that the water comes from the higher ground east of the Delaware and that the direction of flow of the underground water is towards the Delaware and not from the Delaware outward. This fact is very clearly

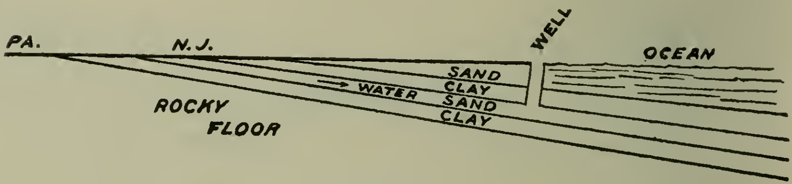


Diagrammatic section, illustrating seepage and growth of streams.

brought out in an article on the "Principles and Conditions of the Movements of Ground Water," by F. H. King. See 19th Annual Report, part II, page 95, U. S. Geological Survey, where he states: "There is a widespread general belief that the level of standing water in the ground is indicated by the level of the waters in the rivers and lakes of the district in question, and that wells must be sunk to those levels before water will be reached by them. It is even commonly thought that the water which supplies the local wells of a region actually seeps into the soil and rock from the beds of rivers and lakes. So far is this common impression from being true that its exact opposite is the real expression of the facts. The surfaces of rivulets, brooks, creeks, streams, rivers and lakes lie below the level of standing water in the ground adjacent to them and from which almost everywhere water is steadily but usually flowing slowly into them. There is a slow but general seepage from the surrounding higher lands."

To quote still further: "It is plain, therefore, that streams winding through the lowest levels of valleys, in regions of humid climates, must receive increments to their volume of water step by step as they move along. It is further evident that low-lying flat areas between higher ground may be made and kept wet by the slow rise of water from beneath as it is forced upward under the hydrostatic pressure developed by the accumulation of water percolating down through the surrounding higher land and in the figure is represented in diagrammatic form the directions of movement of the ground water as it passes downward through the porous soil and outward from beneath the higher areas to seek an outlet in river channels or in the beds of lakes."

In Philadelphia's new water supply the water is taken from the Delaware at Torresdale, then filtered by sand filtration and then carried by an underground conduit ten feet seven inches in diam-



Ideal section, showing alternate beds of sand and clay.

eter and 100 feet below the surface to Tacony where it is piped to Philadelphia. The statement was made in print and attributed to a prominent engineer that the conduit would leak less when the level of the Delaware was high and leak more when the Delaware was low. The idea was there would be more pressure of underground water on the outside of the conduit when the Delaware was high. From what we have just stated the seepage is in the other direction.

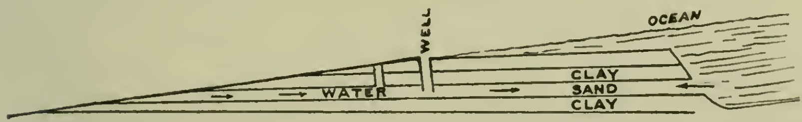
The third proof that it is not filtered Delaware water is: The artesian wells that furnish the water for Camden are not affected by the rise and fall of the tide of the Delaware. As explained before all of these wells are comparatively near the Delaware and if it was merely filtered Delaware water the water in the wells would rise and fall with the tide. Mr. Ridpath, an artesian well driller, who put new strainers on these wells, is authority for the statement that the wells are unaffected by the tides.

It is interesting to note that the artesian wells at seaside resorts

along the coastal plain rise and fall with the tide. In the Annual Report of the State Geologist of New Jersey for 1898, pages 76 and 79, are found the following statements:

"Tidal rise and fall of the water in artesian well at Ventnor, south of Atlantic City—well 813 feet deep—

"After the completion of the well and before the connection with the water supply system a series of observations were made covering a period of three weeks, showing a tidal rise and fall of water in the well regularly following the rise and fall of water in the ocean, and approximately three-fourths of an hour later. These observations were made by James C. Calvert, the Postmaster at Ventnor. A study of his measurements show that the difference between two consecutive tides varied from $7\frac{3}{4}$ to $14\frac{1}{2}$ inches. In the artesian well at Avalon, 925 feet deep, at the northern end of Seven Mile Beach, observations were made during a period of eight days respecting the tidal rise and fall of the water therein. The difference between consecutive high and low

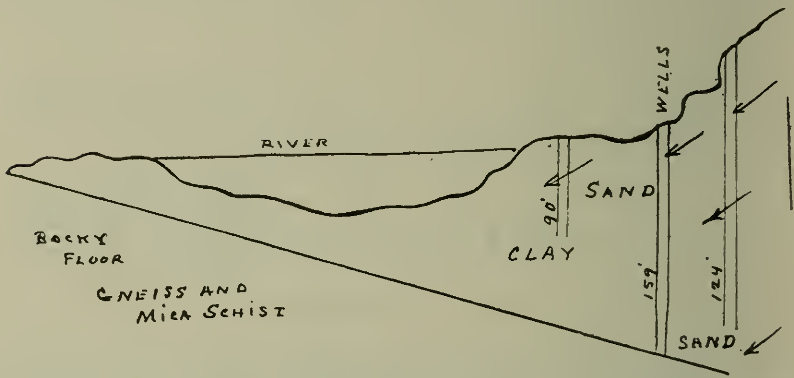


Ideal section, showing how salt water may exert back pressure and force fresh water in the well to rise and fall with the tide.

tides in this well varied from $10\frac{1}{2}$ inches to $15\frac{3}{4}$ inches. Our observations the past season definitely show that the height of water in this and other artesian wells along the coast rises with each high tide to a greater or less elevation according as the tides on the shore are greater or less in height, and similarly falls with each low tide, to a less or greater height in the casing in accordance with a less or greater fall of the tides off shore."

The Avalon well was interesting because it was a flowing well. The water rose about eight to nine feet above the surface, varying in height with the tides and flowed seventy-five gallons a minute. These facts are in accord with what has been said about the seepage or circulation or underground water. It is from the land towards the ocean; were it otherwise we would get salt water in the wells instead of fresh. In fact, there is not the slightest doubt if we were to put down an artesian well in the ocean five miles from the shore, in certain places on the submerged coastal

plain, that we would obtain fresh water after the drill had penetrated the deep clay beds and entered the water horizons in the underlying sands. The various deep clay beds are impervious to water and would keep the salt water from getting to great depths. As an illustration that these beds of clay and marls are continuous for great distances, we might mention that the marl beds which come to the surface in middle Jersey slope or dip towards the ocean and at Atlantic City the borings from the deep artesian wells show that these same marl beds are 800 feet below the sea. The reason the water in wells at seaside resorts rises and falls with the tide may be explained as follows: There is no doubt that the sand horizons which furnish the water, even if they are



No well defined and continuously connected clay beds near the river and wells to make a vertical section. The continuous beds of sand and clay are found to the eastward.

buried at great depths between beds of clay, must appear on the ocean bottom somewhere, even if it be at great distances from the coast in deeper water. This being the case we can understand how the pressure of the sea water would cause the fresh water to rise.

This is merely an ideal section and is not intended to represent beds ending at the edge of the continental platform. How far out these beds extend and where they make their appearance on the ocean floor is not known.

If this rise and fall of water in wells at seaside resorts is due to tides, and we see no reason at present to doubt the statement, because the wells were tested immediately after drilling and before the water was piped to the cities, then we know of no other ex-

planation of the cause of how the tides make the water rise and fall in the well than that given in the diagram.

To return to the Camden wells. It is impossible to make a section showing continuous and alternate layers of sand and clay in the vicinity of the wells because such continuous layers of clay are not found in the Delaware River Valley like they are to the eastward. The Annual Geological Report of New Jersey for 1898, page 110, states: "Between the water-bearing strata of the shallow and those of the deep wells we have not been able after a careful study and the plotting of vertical sections to make out any well defined and continuously connected clay beds; there are, however, many beds of clay between the two horizons which vary in color, being white, red or yellow. In thickness they measure from a few inches to ten feet or more. These clay beds seem to the writer to probably be lenticular in shape and to be interbedded at varying depths between the more open sands and gravels and to be more or less limited in extent so that they cannot be traced continuously across the sections of any great number of wells."

FIRE-PROOF CONSTRUCTION.

A great fire, resulting in the sacrifice of hundreds of human lives and the loss of many million dollars' worth of property, is possible in every city of the United States. The calamities of Chicago and Baltimore might be duplicated in New Orleans or St. Louis. An earthquake in New York equal in intensity to the one in San Francisco would cause an appalling loss of life and property. Investigations made by three of the most competent structural experts in the country have led them to the conclusion that there are no absolutely fire-proof buildings. Not that fire-proof buildings are impossible, for, according to these experts, structural materials may be so selected and used that adequate fire protection is practically assured; but in the effort to cheapen construction in order to obtain greater interest on investments, owners of buildings have neglected or ignored perils to lives and fortunes.

Soon after the San Francisco earthquake, the Interior Department at Washington, through the United States Geological Survey, assigned to Richard L. Humphrey, Secretary of the National Advisory Board on Fuels and Structural Materials, and Prof. Frank Soule, dean of the College of Civil Engineering of the University of California, the task of investigating the action of the fire and earthquake upon so-called fire-proof buildings. At about the same time the War Department assigned a similar task to Capt. John Stephen Sewell, Engineer Corps U. S. A., whose reputation as an expert on fire-proof building construction is international. After a thorough investigation these officials have prepared a careful report, which

has just been submitted to the Interior Department and will soon be published by the Geological Survey. The conclusions presented in this report are of great interest and value.

Mr. Humphrey, emphasizing the fact that the lessons of the Chicago and Baltimore fires are still unlearned, declares that a remedy for existing conditions can be had only by the enactment of strict building laws which will compel fire-proof construction. Professor Soule estimates that the earthquake caused directly less than 10 per cent. of the total loss at San Francisco, and that of the subsequent and indirect effects—the paralyzing of the water supply and its distributing system, the starting of a fire impossible to extinguish with the means at hand, the death of at least 500 persons, the destruction of $500,000,000 worth of propety, and the remoter damages to business, commerce, and labor—nearly all might have been prevented by wise foresight and provision. Capt. Sewell points out the fact that fires and fire tests have proved conclusively the inadequacy of commercial methods of fire-proofing as at present applied.

The recommendations of the experts as to the essentials of fire-proof construction are definite and positive. High, steel-framed office buildings properly braced, are declared to be stable and reliable, and concrete and reenforced concrete structures are placed high among materials well adapted to withstand earthquake and fire, while hollow tiles and hollow concrete, although not in the past universally successful, may be so employed as to yield most satisfactory results. Concrete floors with metallic mesh reenforcements are strongly recommended for strength and fire resistance, and wire glass, metallic rolling shutters, and metallic sash have proved such excellent fire protectors that wise económy demands their use in every important building. Other materials and measures equally important are enumerated, and it is believed that their adoption, while involving increased cost of construction, will insure permanence of structure and at the same time greatly reduce rates of insurance.

A TWENTY-FOUR-CENTURY OLD TUNNEL.

Evidence exists that a work similar to the famous Simplon tunnel, but on a smaller scale, was executed some twenty-four centuries ago. Owing to the bad state of the water supply of Jerusalem, the King ordered a reservoir to be made at the gates of the city, to which water was to be brought from various springs. The Shiloh tunnel, by means of which water was brought down from a source to the east of Jerusalem and poured into the pool of Siloam, was 1080 feet long, and is in a straight line. It has been learned that work was commenced at both ends of the tunnel, and the direction was altered a number of times. The floor of the tunnel is finished with great care. The width varies from 1.9 to 3 ft., and the height from 3 to 9 ft. There is much speculation as to how these engineers gauged their direction so well as to be able to recognize and correct errors in alignment, as was certainly done.—*Iron Age.*

Section of Physics and Chemistry.

(Stated Meeting held Thursday, October 17, 1907.)

Classification and Uses of Cement.*

By Samuel S. Sadtler,

Member of the Institute.

With a view of classifying and studying the subject of cements, the writer has prepared the following discussion. This subject is such a broad one, embracing a wide range of chemicals and raw materials, that the scope of this paper can not go beyond a general treatment of the subject.

Besides cements in the narrow sense, there are other preparations which may also be defined and discussed.

A *cement* is a plastic or liquid substance used to join surfaces. It becomes firm or solid on setting.

A *lute* is a plastic material used for preventing or stopping leaks and is generally used for temporary purposes. Its setting is generally of such a character that it may be easily removed.

Pastes and *mucilages* are fluid substances used for uniting paper and cloth or fastening them to surfaces such as wood or metal.

The purposes for which this class of substances are employed are so many that there is hardly any line of work that is not in a notable measure depending upon them. It is difficult to recall any industry not requiring one or more of them.

Wood workers, masons, plasterers, plumbers, bookbinders, machinists, the metallurgical industries, manufacturers of chemi-

*Read by title.

cals, all industries where power is a large factor, scientists and householders are constant users of cements.

It can hardly be said that there is any dearth of information as to what might be used in special cases or that there is any difficulty in procuring suitable materials for compounding, but it has been thought desirable to treat the subject in a systematic way. This might help persons to choose a cement, to compound it, and to get the best results in its use.

The fact is that there are hundreds of formulas published for making cements, where dozens would serve if careful selection were made by some one and the result properly classified. Of those now published, too much is claimed for some, others are practically impossible, a large number are unnecessarily complicated or use expensive elements where cheaper ones would serve, such as the use of ale or brandy as media of solution. These substances may do the work required, but simpler ingredients naturally suggest themselves and the old formulas should be revised accordingly, provided tests show that the changes are safe ones to make.

SETTING.

To properly use cements it is quite important to understand the rationale of their action. With this knowledge, if the action characteristic of its setting does not proceed satisfactorily, modifications of temperature, dilution or proportions may be made and much trouble saved thereby.

The phenomena of setting may be differentiated as follows:

1. Evaporation, loss of water or other solvent.
2. Hydration, taking on the elements of water.
3. Cooling.
4. Oxidation.
5. Vulcanization.
6. Ordinary chemical action.
7. Combination process.

1. *Evaporation.* In cases where setting takes place by evaporation there are various considerations to be noted in respect to both solvent, solute materials and insoluble filler if any.

The chief consideration is of course as to whether the materials in solution or combined solution and suspension are chemically and physically resistant to solution, corrosion or abrasion

incident to their use. This matter is, however, too full of detail to be taken up at this time. As to the solvent, however, something may be said here.

Layers of cement should not be so deep as to seriously hinder evaporation, especially if the solvent is water. When water is used, unless the time of setting is not important, heat is generally present to expel it, or some corrective filler used, such as Portland cement or plaster. As the solvent goes off cracks are likely to develop if the mixture is too thin. Fibrous materials such as noted below under the head of fillers are useful for holding it together, and if the body of the cement is of soft material such as oils or soft pitch it is especially desirable to have some inert filler present whether fibrous or not. When the solvent is not water, choice of various organic solvents can often be made. In general methyl (wood) alcohol and ethyl (grain) alcohol dissolve soaps, free organic acids and some of the resins, while the other solvents dissolve, more or less perfectly, fats, oils, some resins, pitches and asphalt.

The most important solvents are here given in the approximate order of volatility (with boiling points), solvent power and cost:

Volatility.	*Solvent Power.*	*Cost.*
Sulphuric Ether...35°C.	Sulphuric Ether.	Sulphuric Ether.
Carbon di-sulphide.46°C.	Chloroform.	Ethyl Alcohol.
Acetone...........56°C.	Carbon di-sulphide.	Chloroform.
Chloroform ....61°C.	Carbon tetrachloride.	Acetone.
Methyl Alcohol...66°C.	Turpentine.	Carbon tetrachloride.
Carbon tetrachloride .78°C.	Glacial Acetic Acid.	Glacial Acetic Acid.
Benzol ....80°C.	Benzol.	Turpentine.
Petroleum benzine 100-150°C.	Toluol.	Denatured Alcohol.
Toluol ....111°C.	Acetone.	Wood Alcohol.
Glacial Acetic Acid		Benzol (straw color).
119°C.	Petroleum Benzine.	Toluol (straw color).
Turpentine ......156°C.		Benzine.
	Methyl Alcohol.	
	Ethyl Alcohol.	

A great deal could be said about these solvents. Each one in turn may be the best for certain substances. The classification as to solvent power is very crude but may be of use at times.

Most of these substances are extremely inflammable and form explosive mixtures with air. There are two notable exceptions, however—chloroform and carbon tetrachloride—especially the latter. It will neither burn nor support combustion.

2. *Setting by Hydration.* In this case crystalline substances form *en masse*, by the taking up of water. It is desirable to have as nearly the total amount of water required as possible to secure the greatest density and strength. There should not be too much inert material present to keep the particles of the setting substance apart. The more finely divided the inert material, the less can be used, as the particles of cement itself must coat all the particles of inert material or be between them to effect a bond. If the particles of inert material are of the same degree of fineness only an equal amount, as compared with cement, can be used. When properly graded as to fineness from five to eight times as much by volume of the filler may be used.

The time for setting may be somewhat reduced by using warm water and very little if any excess and may be retarded by having an excess and by the use of small amounts of certain chemicals, alkaline substances, for instance, delay the setting of Portland cement and plaster. In some cases the entire amount of water cannot be used at once or it dries out somewhat, so that subsequent wetting is necessary.

3. *Setting by Cooling.* In this class are considered cements and lutes which are applied in the melted state, such as resins, waxes, bituminous bodies, solid fats and sulphur. The great advantage of using materials in this way is that there is no loss in density as is generally the case where the setting takes place by evaporation. The work they are applied to should be hot, however, or the setting is interfered with.

If the pieces of apparatus to be joined are small it is usually well to heat them well, as applying the cement hot is not enough to insure a fused union of cement and work.

Inert substances are almost invariably used in admixture to make the cement harder, stronger, fill voids and to cheapen it. Clay, sand, asbestos, cement, plaster, whiting, etc., are used in this connection.

Sometimes there is a subsequent chemical action, as when acid resins are used with fillers of a more or less basic character, such as metallic oxides or carbonates.

4. *Setting by Oxidation.* This may take place in oil used or in powdered metal. In the case of oil there is an effect of hardening and consequent setting. With metals it causes an expansion due to increase of volume. The commonly used oils acting in

this way are Chinese wood oil, linseed oil, rapeseed oil and fish oils. In the case of Chinese wood oil, the oxidation is so energetic that it is generally best to mix it with some other oil. Linseed oil is almost always previously "boiled" before use and rapeseed oil "blown."

With regard to the metal powders, iron is the chief one used, although precipitated copper has been used and other metals might be for special purposes. The iron used is invariably the powder resulting from the crushing and sorting of cast borings, filings or millings. They should be nearly free from oil, and the cement has the greatest expansive power when in a finely divided condition.

The value of these cements depends on the expansion taking place in a confined space, such as holes or cracks in castings. This expansion may be so powerful as to break or shatter the object upon which it is used. In such sases it can be diluted with clay or cement. When the holes in a casting are well filled with concentrated iron powder moistened with water containing a very little salt or salammoniac the particles adhere so firmly and the actual oxidation is so limited in actual amount, that the casting can be finished and not show where it was mended. Furthermore, the cement is not dislodged by any ordinary means.

5. *Setting by Vulcanization.* This takes place where fresh rubber is used as a cement in conjunction with sulphur or certain compounds of the same and heated to about 120° C., which renders the rubber insoluble, firm and causes it to lose its stickiness. Vegetable drying oils may be used, such as rapeseed and linseed oils, with sulphur chloride, dissolved in carbon disulphide, as a vulcanizing agent. Hydrochloric acid gas is liberated in this reaction and so zinc oxide or a similar base is generally used to neutralize the acid. In the vulcanization of rubber itself, such precaution must be taken when sulphur or sulphur chloride is used.

6. *Setting by Chemical Action.* Under this classification we have several of the most useful cements known. In most cases, however, the action is too rapid, so that setting takes place before the cement is in position. Dilution of the active ingredients is the general remedy for this. There are also specific ones. As examples of the most useful cements, the oxy-chlorides may be mentioned, which remain nicely liquid or plastic for ample time to use

and then set up very strong and hard. The well-known glycerine-litharge cement acts nicely in this respect. Cements formed from silicate of soda and oxides of lime, magnesia, zinc, etc., and those formed by the action of their oxides on casein and albumen do not act so well. They are liable to set up too soon and be crumbly when set up.

7. *Setting by Combined Action.* The most prominent case of this kind is the setting of glue. In the first place when used it is a melted mass that on cooling has fair strength of coherence and adherence. Then, however, as the water is absorbed by the wood or other material being cemented, it becomes stronger until very great strength is developed when free of water.

Other cases are when a solvent or heat is used with a resin, boiled oil, etc., mixed with a metallic oxide such as lime. There is then the combined action of the evaporation and the formation of new compounds or so-called metallic soaps.

INERT SUBSTANCES.

These useful, harmless substances do not make a cement, but so many formulas differ only in the choice of them that it might be supposed they did. Sometimes a little work is required of them, as when there is a little water to be taken up. Plaster and Portland cement serve this purpose. Zinc oxide and other basic substances, while mainly serving as fillers, absorb acid in addition. In most cases, however, no action of this kind is required and it is merely a matter of giving body or other physical properties.

A classification of fillers may be made as follows:

Corrective.	*Porous.*	*Strength.*	*Finely Divided.*
Portland cement.	Infusorial earth.	Asbestos.	Cement.
Plaster of Paris.	Magnesium carbonate.	Hair.	Clay.
		Plush trimmings.	Plaster.
Zinc oxide.		Cloth.	Gypsum.
Lime.		Tow.	Whiting.
Whting.		Oakum.	Silica.
Magnesia.			Powdered glass.
			" fluorspar.

COMPOSITION OF CEMENTS.

Cements that have come into use to any extent may be placed in classes according to their composition as follows:

1. a. Rubber solutions.
   b. Gutta percha solution.
   c. Pyroxylin solution (collodion.)
   d. Gum resin solutions (such as mastic and copal).

2. Silicate of soda and neutral fillers.

3. a.. Flour pastes.
   b. Starch pastes.
   c. Dextrin pastes.
   d. Gum solutions (such as arabic, tragacanth).

4. a. Plaster of Paris.
   b. Portland cement.

5. a. Bitumens (pitch, tar, asphalts, etc.).
   b. Resins (resin and gum resin in melted state).
   c. Sulphur.
   d. Shellac.
   e. Rubber and gutta percha, melted or thinned with oil.

6. Iron powder compositions.

7. Drying oil mixtures.

8. Oxy chloride cements.

9. Glycerin and sugar compounds of lead.

10. a. Glue.
    b. Casein.
    c. Albumen.

11. Cements made from metallic oxides and strong acids.

12. a. Vitreous and vitrifying mixtures.
    b. Clay and asbestos, etc., with water.

Class 1—a, b and c are especially waterproof, tough and tenacious. d is not so tenacious but answers the other requirements, adheres better to smooth surfaces, has greater hardness when set, and is transparent in thin layers in which it is frequently used for optical purposes. a, b and c are generally made up with fillers to prevent the formation of voids on the evaporation of the solvent.

Class 2. Not waterproof, but form very dense, hard and strong lutes. Especially good for hot gases, in which case the water of the silicate can go off. They are useful for organic solvents and stick only too well to glass. Suitable fillers are

barytes, whiting, silica, powdered glass and powdered fluorspar. The three latter probably slowly react with the silicate with beneficial results.

Class 3. Are used for fastening paper and cloth.

Class 4. This is a most important class. a is generally used without filler, although frequently mixed with alum, etc., for purposes of increasing the density. It is used for filling hollow articles, moulds, etc. b is the most used of all cements. It is made into concrete for building purposes, etc. For use in small amounts it is not successful as the water dries before it can set.

The making of cement concrete waterproof is an art not understood by all. The main points to be considered are to have the voids as few as possible and the dense coating on the side the water would enter. Neat cement is probably most used for this denser coating. It should be used as strong as it will flow well into crevices and hot if possible. The condition of the work and the kind of cement are important. It is waterproofed best when fresh, and if washes such as silicate of soda, skimmed milk and casein solution are used an over-limed cement is desirable. Magnesia cement has been recommended for this purpose, but the chloride is liable to soak in and not combine properly with the oxide.

Class 5. This is a very important class, if the number of formulas are a criterion. The materials must be applied in melted condition. The marine glues are made from materials of this class. Sulphur is much used by itself and sealing wax is also of this class.

Class 6. The use of this material has been referred to above.

Class 7. Putty and red lead compositions are among the best known cements. Boiled linseed oil is invariably used and if rosin is dissolved in it and metallic oxides mixed therewith a much thicker composition is obtained thereby than otherwise. When very much oxidized by exposure to heated air in their films and mixed with powdered cork, etc., linoleum can be produced.

Class 8. Oxy-chloride of zinc has been used for dental purposes and forms a very dense, strong, stone-like cement. Oxychloride of magnesium is, however, more used, as the ingredients are cheaper. It is used for uniting particles of stone either for

refacing the same or make an artificial stone, for making compositions with saw dust for a kind of floor tiling.

Class 9. This class is a valuable one, embracing the well known glycerine and litharge cement, much used for joining glass to metals, etc. It is waterproof, acidproof, gasproof and not attacked by organic solvents.

Class 10. Casein and albumen form very strong compositions with lime, zinc oxide, etc. They set up very quickly, so must be used at once. They are more in the nature of lutes than cements properly considered.

Class 11. The combination of zinc and other oxides and phosphoric acid stands for this class. It is much used by dentists and forms a hard, dense, waterproof substance.

Class 12. This class includes glass powders or glass forming mixtures that bind surfaces at high temperatures.

With a view of choosing a cement only the most general statements can be made here. In two previous papers* details of formulas have been given by the writer.

The following suggestions may be of use however, the numbers referring to the classification on page:

Hot surfaces, 2, 4a, 9, 10 and 12.

Elastic, 1a, 1b.

Water and steam, 5a, 5b, 5e, 6, 7 and 9.

Strength, 2, 4b, 8, 9, 10a and 12.

Expanding, 4b and 6.

Quick setting,

Acidproof, 1a, 1b, 1c, 2, 5a, 5b, 5c, 5e, 9.

High temperature (moderate), 4b, 6.

High temperature (excessive), 12a, 12b.

COST OF MATERIALS.

The writer has known of many instances of people being disappointed at preliminary inquiries into the cost of materials used for experimentation. In some cases probably abandoning a line of work, as they thought that it would not be economically possible on a large scale.

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*Jour. Franklin Inst., May, 1904.

*Trans. Eng. Club of Phila., *21* (1904), 315.

The druggist or other retailer must frequently put up the few ounces of chemicals asked for in bottles or cartons at the price per ounce the goods sell for per pound in large lots.

For the benefit of those however who do not follow the market quotations a brief table of the costs of the most used materials is here given. These figures are mostly fluctuating but close enough to be a general guide. They are figures for ton or drum lots:

Material.	*cts. per lb.*	*per gal.*
Acetic acid	12	
Acetone	19	
Alcohol, denatured		40
Alcohol, wood		40
Albumen, blood	30	
Albumen, egg	75	
Alum	2	
Alum (conc.)	2	
Ammonia (aqua)	6	
Asbestos	5	
Asphaltum (ref.)	4	
Barytes (floated)	1	
Bayberry wax	28	
Beeswax	40	
Benzine		18
Benzol (straw)		25
Borax	9	
Carbon disulphide	7	
Carb. tetrachloride	12	
Casein	9	
Chinese wood oil	8	
Chloroform	35	
Clay (finer grades)	½-1	
Copal (sorts)	60	
Dextrin (corn)	3	
Formaldehyde	9½	
Gum arabic	10-35	
Gum mastic	50	
Gum tragacanth	45-70	
Glue, hide	12	
Glue, bone	9	

Material.	*cts. per lb.*	*per gal.*
Glycerin	14	
Gutta percha	2.50	
Iron oxide	3½	
Iron powder	5	
Japan wax	14	
Lamp black	6-35	
Lime	1/5	
Litharge	8	
Linseed oil		45
Magnesite (calc.)	2	
Magnesium chl'ide	1½	
Nitro cellulose	50-1.00	
Pitch		3.50 per bbl
Plaster of Paris		1.50 " "
Rape seed oil		75
Red lead	8	
Rosin	2	
Rubber	1.50	
Shellac	45-65	
Soda-silicate	¾	
Soda, caustic	2	
Sulphur	3	
Sulphuric acid	1½	
Stearic acid	14	
Stearine	7	
Tannic acid	40	
Turpentine		61
Whiting	2	
Zinc chloride	5	
Zinc oxide	6	

DETAILS OF USE.

It is a matter of importance that a cement be used under favorable conditions. It might seem superfluous to say that the "work" should be clean, but in large factories there is frequently a great deal of dust, moisture, grease, etc., that deposits on pipes and other places where joints are to be sealed.

Air films should be displaced by heating the "work." This prevents a chilling of the cement, which might fail to adhere if not

fused into the surfaces where applied. Some writers have insisted upon this heating as a *sine qua non* of success. But it is manifestly impossible in some cases. An alternative to this is to paint the surfaces to be joined with a solution of the chief constituent of the cement. A benzol solution, for instance, of pitch, oil, rosin, etc., can be used. If silicate of soda, glycerine or magnesium chloride are the liquid elements, water can be used as solvent for this painting.

Surfaces should fit as closely as possible before the cement is used. Use as little cement as possible.

Preservatives such as sodium salicylate, benzote or an essential oil may be used in small amounts for pastes and mucilages that would spoil otherwise on exposure. It is a good plan to have some cements or lutes most used for any particular line of work made up ready to be mixed or applied.

Laboratory of Samuel P. Sadtler & Son,
Philadelphia, Pa., October 1, 1907.

CANADIAN BOUNTY FOR ELECTRIC SMELTING.

Toronto, April 6, 1907.—A resolution was introduced into the House of Commons by the Finance Minister on Thursday declaring it expedient to provide for the payment of bounties on pig iron and steel manufactured by electrical processes. The adoption of the resolution is, of course, not the same thing as the passage of an act on its third reading, but it is a practical certainty that the measure into which the resolution is to be turned will become law. Last week the opinion was hazarded in this correspondence that no special bounty for electrically-produced pig iron or steel would be proposed by the Minister, and the bounties provided for in this resolution cannot well be described as special. They are simply an application and a time extension of the bounties now paid upon pig iron and steel produced by established methods. The terms of the resolution are as follows:

That it is expedient to provide that the Governor-in-Council may authorize the payment out of the consilidated revenue fund of the following bounties on pig iron and steel ingots manufactured in Canada for consumption therein, when such pig iron and steel is the product of Canadian iron ores smelted in Canada by electricity, viz.: on pig iron manufactured from Canadian ore by the proces of electricity smelting during the calendar years: 1909, $2.10 per ton; 1910, $2.10 per ton; 1911, $1.70 per ton; and 1912, 90 cents per ton. On steel ingots manufactured by electric process direct from Canadian ore, and on steel ingots manufactured by electric process from pig iron smelted in Canada by electricity from Canadian ore during the calendar years: 1909, $1.65 per ton; 1910, $1.65 per ton; 1911, $1.05 per ton; and 1912, 60 cents per ton.

It is apparently the intention of the Finance Minister to give the manufacturers by electrical processes a clear four-year period of bounty assistance of exactly the same kind as that now remaining for the blast furnace and steel works owners. For pig iron manufactured by the regular method from Canadian ore to bounties, it will be remembered, are as follows:, in 1907, $2.10 per ton; 1908, $2.10; 1909, $1.70; 1910, 90 cents.

For steel ingots of which not less than 50 per cent. of the weight is derived from pig iron made in Canada, the bounties are as follows: In 1907. $1.65 per ton; 1908, $1.65; 1909, $1.05; 1910, 60 cents.

It will be seen that the new bounties on electrically-produced iron and steel are to be at the same rate as those provided for iron and steel otherwise produced, the difference being that the four-year period for the electric products does not begin until 1909, whereas that for iron and steel produced by the ordinary methods began on January 1 last. It is probably assumed by the Government that the intervening period of twenty months is not too long to allow for the establishing of electrical smelters and converters. But should any begin operations within that time their output would be entitled to the current bounties of $2.10 and $1.65, respectively, on pig iron and steel ingots, however produced.

Besides the results of experiments carried on with the aid and under the supervision of the Government at Sault Ste. Marie, laboratory work elsewhere appears to have successfully demonstrated the feasibility of treating some of the most unpromising of Canadian iron ores by electrical processes. It is stated that while the tests at Sault Ste. Marie were in progress private parties were proving the practicability of the electrical smelting of titaniferous ores in Quebec. These parties are reported to be in touch with New York and London capitalists.

R. Turnbull, a Scottish engineer, who was associated with the experiments at Sault Ste. Marie, proposes to erect a plant at Welland, in this Province. He undertakes, if adequate bounties are granted, to have his plant in operation a year from next July. N. Thompson, who went from Canada to England last year, succeeded in interesting capital to establish an electric smelting plant at Bow, near London. He is now back in Canada and proposes, if sufficient Government aid is given, to form a company for the electric smelting of iron ores in British Columbia.—*Iron Age.*

LIGNITES IN IDAHO.

Lignites occur at a number of places in Idaho, but only within the last two or three years have any of these beds been extensively mined. Mining has been done in the Horseshoe Bend and Jerusalem districts, occupying the lower portion of a ridge between the Boise and Payette Rivers; in a district near Salmon City, in Lincoln County; and in one at the eastern edge of the State, in Bingham and Fremont Counties, where the Sublette fields of Wyoming extends across the State line. According to E. W. Parker, of the United States Geological Survey, the principal production in 1905 and 1906 was from the Salmon district, in Lemhi County, 4380 short tons having been mined there in 1905, and 4395 short tons in 1906. The total production for the State in 1906 amounted to 5365 short tons, having a spot value of $16,538.

(Stated Meeting held Thursday, October 17, 1907.)

The Jerseyite.

By Dr. E. Goldsmith,

Member of the Institute.

On the 30th of April, 1906, a fisherman of New Jersey saw a meteoric fire ball pass overhead with a hissing noise and, travelling up the Lower Delaware Bay, fall on the New Jersey shore.

He went to the point where he believed he saw it fall and found it at low water, about twelve miles north of Cape May Light.

He brought two pieces of it to the Academy of Natural Sciences of Philadelphia, where he wanted to learn of what the matter was composed. There, to his astonishment, he was told that the material was not of meteoric origin, because it has no external pitting and, as they believed, it had the appearance of a mill-cinder.

So the mineral was labelled and put into the collection. I confess that when the specimen was shown to me several months later it gave me the impression that it might be furnace slag. However, knowing from many years of experience that matter cannot be determined by mere inspection, I made up my mind to ascertain the true nature of the mineral by the crucial tests of physics and chemistry.

Prof. Pillsbury, to whom my thanks are due, kindly handed to me a part of the sample brought by the finder (whose name I think is North.) On observation it was found that the sides were furrowed by longitudinal crystalline impressions, indicating that it must have been heated and partially melted. At one end a mass of the same material apparently and of the same structure

is attached to the specimen at right angles, giving it the appearance of an artificial make-up.

The substance is brittle, and with the aid of a chisel and hammer a piece was broken off, ground plane on one side on an emery wheel in a machine shop and polished on plate glass with rouge and water until light was reflected; then, after washing, etched in diluted nitric acid.

The result of this treatment was the appearance of the Wittmaustedten figures; and, on more minute observation, it became evident that the whole mass was crystallized.

Now this structure, viz:—the Wittmaustedten figures, has never been observed in a mill-cinder or in furnace-slag from either a blast or open hearth furnace, nor in any manufactured iron or steel, nor any alloy whatsoever, for I have had the opportunity of observing many hundreds of specimens of all sorts of metals and their alloys under the same condition of polished and etched surfaces and never detected the presence of any crystallization which could be compared with the Wittmaustedten figures. Therefore, when these figures appear under the conditions as stated, they are an absolute proof that we are dealing with matter derived from space, i. e. extra-terrestrial.

This test has been known for nearly a hundred years, and has been overwhelmingly proved to be correct. There are few objectors to this rational test.

For my part, I feel confident in stating that the Wittmaustedten figures occur only in matter derived from interstellar space.

The hardness of this meteoric stone is about the same as that of microcline, that is = 6. The specific gravity was found to be = 3.636. The color of this crystalline mass is nearly black. The polished surface of the specimen reflected diffused light grayish white; sunlight as well as the white light from the Welsbach mantel burner gave the same peculiar gray reflection. That a modification of the rays of white light had been effected by the black shining surface was evident; but, what was the cause of this difference? Evidently some of the spectral rays must either have been absorbed or had never entered the material; in either case the reflected rays differ! In order to ascertain this point, I had recourse to the spectroscope. It is evident that if all the rays of sunlight had entered the material they would be reflected. Let us see what the spectroscope answered.

When the light is reflected from the polished specimen into the narrow slit of the collimator, then passed through a diffraction grating and observed with the telescope in focus and strictly optical line, the centre of the phenomenon has the same appearance, that is to say, grayish-white rays are visible; but, when we search on the left and right from the centre, only a partial spectrum, the green and some blue rays become visible. The green ray was measurable; the blue not. From the centre to the green ray the arc was $=3^{0}2^{1}$ approximately, hence the wavelength $\lambda = 529 \times 10^{7}$. Comparing this result with the published Angstrœm's Charts, we find that the ray measured is in the neighborhood of the Frauenhofer line E.

If the slit of the collimator is further opened, then yellow, orange and red rays enter the field. But what became of the indigo and violet rays? They are simply absent; they never entered the material and could therefore not be reflected. We have the answer now why the reflected rays from the black polished surface were grayish. True, white light must have all the seven rays of the spectrum, otherwise it is not complete. When only a part of the white light enters a substance, how can we expect that the whole of the white light should be reflected?—it would not be in accordance with the laws of the conservation of energy.

We may imagine that the intensity of the light employed has something to do with the above result. When I reflected an electric arc light from the polished surface of the Jerseyite and observed the same with a transparent replica of a diffraction grating held before the eyes, I saw the two carbon points and the nearest ray to them was blue, then green, yellow, orange and red; but the indigo and violet rays were absent, showing that even the intense electric arc had no better effect than the white glow of the Welsbach gas burner. When the reflected gray ray issuing from the same black surface is allowed to pass through a Nicol prism, we see that the ray is partially polarized; we have, therefore, elliptic polarization by this substance.

The material in question is but slightly magnetic. Although the substance is very brittle, I succeeded in preparing a thin section for the microscopic examination. Under the microscope I was rather surprised to discover two distinct forms of the matter; the one in well defined crystals and transparent, while the other was opaque and amorphous.

The etching process by diluted acid is now understood, for not only diluted nitric but also hydrochloric acid will penetrate it, whether polished or not, attacking the fine amorphous powder only and not touching nor affecting the crystal in mass. The form of the crystals is fairly well outlined; they seem to belong to the Orthorhombic system. The planes [110], [001], [010], [111] were recognized. The crystals form chain-like rows in such a manner that apparently each individual is separated from its neighbor by a black line of the amorphous non-transparent fine powder.

In polarized light these prismatic forms readily transmit the rays when inclined to the longer axis, and extinguish completely all light when brought parallel to the plane of polarization.

Mr. Arthur T. Collins volatilized fragments of the Jerseyite in the electric arc and projected the incandescent vapor on the collimator slit by means of lens in the hope of seeing whether the coronium line would appear in the field of vision. He reported to me that the result was negative. But, as is usually the case under these conditions, elements are detected which the chemical analyst cannot separate. The incontestable proof was given that barium, calcium and lithium were present. These elements, easily detected by the spectroscopist, could not be found by the analyst on account of the small quantity contained in the mass.

In this connection a singular phenomenon was observed not commonly met with:—When the arc between the carbon rods—the lower one supporting the fragment of the Jerseyite—began to glow, a thick volume of mineral vapor appeared; viewed now in the spectroscope the two sodium lines stood out sharply and each of them partially absorbed, i. e. the black Frauenhofer D-line coincided upon the yellow Na-line, a fact which Mr. Collins observed first and to which he directed my attention.

This singular double prenomenon seems to be due to the fact that the thick vapor sphere farthest away from the white hot carbons cools somewhat and partly absorbs the incandescent yellow Na-vapor. There is nothing new in this view, because it is essentially the Bunsen effect; but to find the reversion of the sodium line under these conditions seems worth recording.

The blowpipe test gave me the following indications: Silica, Titanic Acid, Iron, Copper and Tin.

THE CHEMICAL COMPOSITION.

The chemical analysis was performed by my esteemed friend Mr. W. J. Williams, a work which required considerable time and circumspection and to whom my thanks are due.

His results here follows:—

Silica,	SiO_2	42.80	per cent.
Titanic acid,	TiO_2	1.90	"
Tin oxide,	SnO_2	0.49	"
Bismuth oxide,	Bi_2O_3	0.22	"
Copper oxide,	CuO	0.26	"
Nickel oxide,	NiO	2.00	"
Iron	Fe	44.36	"
Aluminum oxide,	Al_2O_3	4.18	"
Calcium oxide,	CaO	Trace (doubtful)	
Potassium oxide,	K_2O	0.92	per cent.
Sodium oxide,	Na_2O	0.80	" (by difference)
Carbon,	C	1.84	per cent.
Sulphur,	S	0.34	"
Phosphorus,	P	0.12	"
		100.23	"
Deduct O=P+S		.23	"
		100.00	"

We see that in the Bausch analysis the essential elements had been recognized by the blowpipe tests.

The carbon is probably contained in the black amorphous powder surrounding the crystalline forms, which make up the principal part of this meteoric stone.

THE PRODUCTION OF ASBESTOS IN 1906.

Commercial asbestos includes two distinct types of fibrous minerals. The term asbestos was originally applied to actinolite or tremolite, but the more important asbestiform mineral is the fibrous variety of serpentine known as chrysotile. This variety is always associated with serpentine which is derived from the alteration of eruptive rocks. It has been reported as occurring in commercial quantities in Massachusetts, Vermont, North Carolina, Wyoming, Arizona, Washington, Oregon, and California.

The eastern townships of the province of Quebec furnish the greater part (85 per cent.) of the world's production of asbestos. In 1906 Canada exported 59,864 tons of asbestos, valued at $1,629,257, most of which came to the United States. Improved methods of mining are being introduced in Canada and the output there is increasing.

Both forms of asbestos are applied to many uses, depending in part upon the fibrous character of the material, but also upon its non-conductivity of

heat and electricity. The best grade of chrysotile fibre is spun into thread, yarn, and rope, and woven into cloth. The yarn is largely used for packings and the cloth for theatre curtains, while fabrics containing asbestos woven with other fibers are made into various household articles in which heat insulation rather than fire-proof character is required.

Asbestos is extensively used for plastering and for making lumber that is employed in buildings where insulation against fire and electricity are desired. Its use in fire-proof structures, and especially to envelop electrical conductors, is constantly increasing.

The production of asbestos in the United States in 1906 was 1695 tons, valued at $28,565, as against 3109 tons, valued at $42,975, in 1905. The imports in 1906 were valued at $1,076,170.

The output of all existing asbestos mines is insufficient to supply the demand for this product, and the leading manufacturing firms interested in the industry are diligently searching for new deposits.

An advance chapter from "Mineral Resources of the United States, Calendar Year 1906," on the production of asbestos in 1906, by J. S. Diller, is now ready for free distribution.

PRODUCTION OF MONAZITE AND ZIRCON IN 1906.

Monazite is of commercial interest as a source of the rare metal thorium, which is used in the manufacture of Welsbach and other incandescent mantles for gas lights. Deposits of this mineral have been found in North Carolina, South Carolina and Georgia, and in several States of the Far West. It is mined in North and South Carolina, the production in 1906 having been 847,275 pounds, valued at $152,560, as against 1,352,418 pounds, valued at $163,908 in 1905, the figures for both years including a small quantity of zircon.

The area in which minable deposits of monazite have been found is growing yearly, especially southwestward, in which direction it now reaches to the Georgia line.

Zircon has been obtained in quantity as a by-product from monazite concentrates. An experimental concentrating plant of the United States Geological Survey at Chapel Hill, N. C., is now making tests as to the best method of separating zircon and other products of commercial value from monazite concentrates. The output of zircon in 1906 all came from Henderson County, N. C.

An advance chapter of "Mineral Resources of the United States, Calendar Year 1906," by D. B. Sterrett, on the production of monazite and zircon during that year, is now ready for distribution.

The British consul at Goa reports that six concerns have commenced mining operations on the manganese deposits of Portuguese India.

Mining and Metallurgical Section.

(Stated Meeting held Thursday, October 3, 1907.)

Deflocculated Graphite.

By E. G. Acheson,

Member of the Institute.

In the year 1901 I was engaged in a series of experiments having as their object the production of crucibles from artificial graphite. In this work I was led into a study of clays. What I learned may be briefly stated as follows:

1st.—The American manufacturers of graphite crucibles imported from Germany the clay used by them as a binder of the graphite entering into the crucibles.

2nd.—The German clays are much more plastic and have a greater tensile strength than American clays of very similar chemical composition.

3rd.—Residual clays—those found at or near the point at which the parent feldspathic rock was decomposed—are not in any sense as plastic or strong as the same clays are when found as sedimentary clays at a distance from their place of origin.

4th.—Chemical analysis failed to account for those decided differences.

I reasoned that the greater plasticity and tensile strength were developed during the period of transportation from the place of their formation to their final bed, and I thought it might be due to the presence of extracts from vegetation, the washings from the forests being in the waters which carried them.

I made several experiments on clay with extracts of plants, tannin being one of them, and I found a moderately plastic, weak clay, when treated with a dilute solution of gallotannic acid or extract of straw, was increased in plasticity, made stronger,—in some cases as much as three hundred per cent.,—required but sixty per

cent. as much water to produce a given degree of fluidity, was caused to remain suspended in water and made so fine that it would pass through a filter paper. Being acquainted with the record of how the Egyptians had the Children of Israel use straw in the making of bricks, and how they substituted stubble for straw, and believing it was not used for any benefits derivable from the fibres but for the extract, I called the clay so treated "Egyptianized Clay."

Having in 1906 discovered a process of producing a fine, pure, unctuous graphite, I undertook to work out the details of its application as a lubricant. In the dry form, or mixed with grease, it was easy to handle, but I wished it to enter the entire field of lubrication as occupied by oil. In my first efforts to suspend it in oil, I met the same troubles encountered by my predecessors in this line of work,—it would quickly settle out of the oil. It obeyed the same laws covering the natural product.

So things stood until the latter part of 1906 when the thought occurred to me that tannin might have the same effect on graphite that it did on clay. I tried it with satisfactory results. the effect being obtainable with the natural graphites as found in the Ticonderoga and Ceylon varieties, and with the artificial product as found in Acheson-Graphite. It was more easily and cheaply produced when the soft, unctuous variety of my graphite was used, this kind being composed of pseudomorphs of carbide crystals, which had been decomposed in the electric furnace, the resultant graphite being very loose, porous and readily disintegrated and deflocculated. The effect was produced by treating the graphite in the disintegrated form with a water solution of tannin, the amount of tannin being from three to six per cent. by weight of the graphite treated. The results are much more pronounced when the mass of graphite, water, and tannin has been pugged or masticated for a considerable time, I having to advantage carried on this process continuously, without interruption, for a period of one month. I have also found that while the effect may be produced in a very satisfactory way with distilled water, the waters as found in rivers, deep wells, etc., are improved by the addition of a trace of ammonia. The presence of carbon dioxide in the water will prevent deflocculation.

The accompanying Figures 1 and 2 show the effect of tannin in suspending graphite. Figure 1 is that of two test tubes, one

containing water, a drop of ammonia and disintegrated Acheson-Graphite, the other tube containing a similar amount of water, ammonia and graphite, with the addition of a little gallotannic acid. The photograph was taken immediately after the tubes were thoroughly shaken. Figure 2 shows the same tubes and contents, four minutes having elapsed after being shaken, they not having been disturbed during that interval. These tubes furnish a very clear demonstration of the quick settling of graphite in plain water and the remarkable effect of the presence of tannin.

All of the graphite put into the tube with the tannin did not remain suspended. In fact, in this case, as illustrated, very

Fig. 1

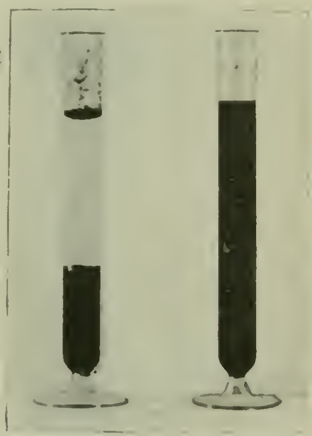


Fig. 2

nearly all of it had settled, only sufficient remaining in the water to give it its blackness. To cause a complete suspension of all the graphite necessitates prolonged mastication in the form of a paste with the water and tannin, and I find that after this mastication has been carried out that the effect is very much improved by diluting the mass with considerable water, and allowing it to remain some weeks with occasional stirring.

After the prolonged masticating and additional time of exposure of the graphite to the water and tannin, an intensely black liquid is obtained consisting of water, a small amount of tannin and graphite; the latter may be present in varying amounts. In this condition I call the graphite "deflocculated," a state of sub-

division much finer than possible of attainment by mechanical means, one that may perhaps be correctly spoken of as molecular. It is in that condition called "colloidal." This term, however, does not appeal to me, being only the name of a condition or state. The term "deflocculated" is much more readily understood, and, to an extent, it carries with it its own definition. I have found this liquid would pass throught the finest of filter papers, and the contained graphite would remain in suspension for weeks and months,—apparently for all time. One per cent. of graphite content makes the liquid so thick that it runs through the filter paper slowly; reduced to 0.2 of one per cent., it goes through quickly.

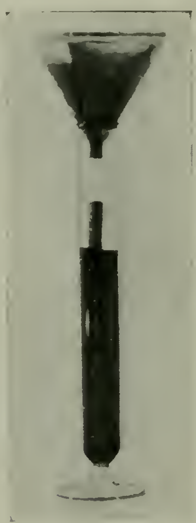


Fig. 3

Fig. 4

Figures 3 and 4 illustrate an experiment with water containing 0.2 of one per cent. graphite. Figure 3 shows a glass funnel containing a fine filter paper resting in a test tube. In the tube below the funnel is a black liquid, which has passed through the filter paper. This black liquid is water containing 0.2 of one per cent. deflocculated Acheson-Graphite. The fact of its having passed through the filter paper leaves no doubt in our minds of the impossibility of separating the water and graphite while in this condition by ordinary filtration. I have found that the addi-

tion of a very minute amount of hdyrochloric acid causes the contained graphite to flocculate, i. e. group its molecules into masses so that it will no longer pass through the paper. Figure 4 shows, as in the former case, the funnel, filter paper and test tube; but now in the lower part of the tube, below the filter, we find a clear liquid, this being the water in which the deflocculated graphite was formerly suspended, the graphite now being caught entirely in the filter paper above. It will be noticed that the filter paper in Figure 3 is black on the outside, this having been produced by the deflocculated graphite passing through the paper, whereas the filter paper, as shown in Figure 4, remains white on the outside, the graphite not having passed through its body.

This effect is obtainable with non-metallic amorphous bodies generally, having been secured with silica, alumina, lamp-black, clay, graphite and siloxicon. An interesting line of thought may be entered into as to the part this effect plays in nature's economy. It is by this means Nature prepares the Potter's clay.

This graphite, even after flocculation, is so fine in its particles that when dried *en masse* it forms a hard article. It is self-bonding, like a sun-dried clod of clay.

I have successfully used deflocculated graphite in water instead of oil in sight-drop feed oilers and with chain feed oilers. I have a shaft in my laboratory measuring 2 5-16″ in diameter, revolving at 3000 revolutions per minute in a bearing 10 inches long that had no oil on it for a month, deflocculated graphite and water being the only lubricants used, the feed being by chain, and it ran perfectly. On the same shaft is a similar bearing lubricated with oil, and this ran much the warmer of the two.

A few days after this test was started a pessimistic friend remarked that just plain simple water would give the same results, that the presence of graphite was unnecessary. We are influenced by the opinions of others even when we know or think they are wrong. I emptied the oil out of the second bearing on the shaft and substituted plain water. The results during the first twelve hours seemed to support the contention of the friend. The next day after the machine had stood motionless over night, things did not look so well for the water; it was a lame "second" on account of rust, and was hurriedly removed. I think I shall not recommend clear water as a permanent lubricant.

Deflocculated graphite in water possesses the remarkable power of preventing rust or corrosion of iron or steel. This character-

istic will unquestionably make it of great value for some uses, and while, as yet, little has been done to explore the field, some work has already been accomplished in using it as a cutting compound in screw cutting, and I have been advised by one large manufacturer that the results obtained showed it to be equal or superior to lard oil when the water was carrying as little as one-half of one per cent. of its weight in graphite. It will readily be understood that while preventing rusting, the high specific heat of the water renders it of great importance, permitting of a high speed of the machinery, and consequently increased output. Another probable application of deflocculated graphite in water will be as a lubricant for condensing engine cylinders.

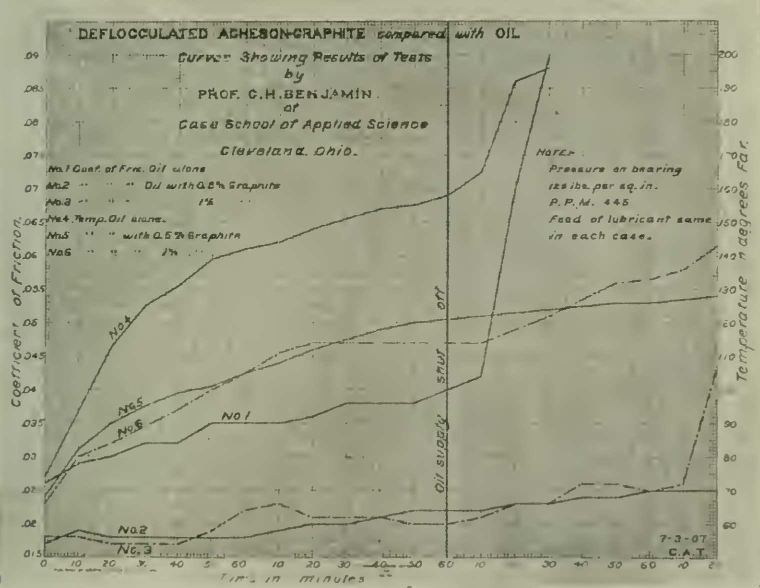
While, as I have stated, deflocculated graphite in water is an excellent lubricant for light work, it has the disadvantage of losing its water by evaporation, and I realized that to utilize the possible advantages of deflocculated graphite, it would be necessary to replace the water with oil; therefore, I set before me the task of accomplishing that result. When it is remembered that a removal of the water by evaporation previous to its replacement by oil would cause the contained graphite to assume the condition of a hard, flocculated, self-bonded mass, it will be seen that the problem was not simply one of the evaporation of the water and suspending the resultant dry graphite in oil. A very great deal of difficulty and many discouraging conditions were met with in my attempt to cross this apparently bottomless chasm, and I am pleased to say that I eventually succeeded, and I have been successful in suspending the deflocculated graphite in oil in a dehydrated condition. The graphite will remain suspended in the manner that it formerly did in the water, and we now have in this article a truly new lubricating body.

A new material having been created, as this would evidently seem to be, a new name is necessary, and I have added the initial letters of Deflocculated Acheson-Graphite, D-A-G, to "Oil" or "Aqua," when the deflocculated graphite is carried in oil or water as the case might be, and have "Oildag" and "Aquadag" respectively.

Prof. C. H. Benjamin, formerly of the Case School of Applied Science, Cleveland, O., and now Dean of the Engineering School of Purdue University, is engaged in making extensive tests to determine the value of deflocculated graphite as a lubricant, and,

while these tests are not as yet completed, he has proved that 0.5% by weight of this graphite in oil greatly reduces the co-efficient of friction and materially extends the life of the oil in which it is suspended as a lubricant. Figure 5 shows some of the results obtained in his tests with spindle oil, and by a study of them we find that comparing the initial co-efficient of friction of plain oil and oil containing one-half of one per cent. of graphite, the co-efficient of friction of the oil containing the graphite was

International Acheson-Graphite Co., Niagara Falls, N. Y., U.S.A.



Initial Friction Oil and 0.5 per cent. Graphite . . .	65 per cent. of oil alone
After 120 m. Friction " " " . .	55 " "
Friction of Oil increased	54 per cent.
Friction of Oil and Graphite increased	30 "
After lub. was shut off friction of oil increased	125 per cent. in 30 min.
After lub. was shut off friction of oil and graphite . .	14 " " 80 "

Spindle oil was used in all tests

but sixty-five per cent. of the plain oil, while after one hundred and twenty minutes, it was but fifty-five per cent., the friction of the oil having increased fifty-four per cent., while with the contained graphite it increased but thirty per cent. After shutting off the supply of the lubricant on the bearing, the co-efficient of

friction of the oil alone increased in thirty minutes 125%, whereas the co-efficient of the oil with one-half of one per cent. of graphite increased in eighty minutes but 14%. In fact, at the end of the entire run of 200 minutes its co-efficient of friction was less than the initial friction of the plain oil.

I have myself been making tests of the efficiency of my product as a lubricant for automobile gasoline engine cylinders, with the result that I very materially reduced the consumption of oil. A Packard No. 30 automobile that I am operating ran over 4,000 miles without the necessity of cleaning the spark plug, and what is still more remarkable, without the necessity of grinding the valves. The usual practice being to clean the plugs and grind the valves at least in 1500 miles. It would perhaps be too early to state positively that the use of Oildag in the gas engine would eliminate the pitting of the valve seats, but the results that I have so far obtained would rather indicate such a possibility. The surfaces produced on the valve seats are remarkable, being much finer than is possible of attainment by any mechanical finishing, the graphite being incorporated in the body of the metal.

PRODUCTION OF MICA IN 1906.

Of the minerals composing the group called mica practically but two—muscovite or potash mica and phlogopite or magnesia mica—are industrially important, and only one of these, the muscovite, is found in deposits of commercial value in the United States. This muscovite is widely disseminated in small plates and crystals, of no value, in crystalline igneous and metamorphic rocks, as well as in the sediments derived from them, but the commercially valuable deposits are confined to pegmatite—a rock closely allied to granite in composition, composed of feldspar and quartz, with more or less mica and other accessory minerals, but unlike granite in that its minerals are crystallized out in large masses. Among the coarser products of this crystallization is the mica, blocks of which more than a yard in diameter have been found

The properties which give mica its value to the world of industry are its perfect cleavage, the toughness, flexibility, and elasticity of its cleavage sheets, and its transparency and non-conductivity of electricity. The three principal uses of the material are for electrical insulation, glazing, and decoration. The first-named use probably leads in present importance, but the other two uses date back to ancient times, mica antedating glass and also being early used to secure decorative effects. As an insulating material it occupies a place that cannot be filled by any other substance. Recently the

utilization of scrap and waste mica in the manufacture of lubricants for car axles has become a somewhat important industry in the West.

The increasing use of the material has largely modified the demand made upon the mining industry, for not only can sheet mica of small size now be utilized, but even more important is the extensive use that is now made of composite mica, molded mica, "micanite," and other varieties of built-up sheets. Scrap mica is also utilized in the manufacture of a superior quality of boiler lagging, and ground mica is used in somewhat increased quantities in mica bronzes and paints and as an absorbent for explosives. The finest ground mica, or mica flour, finds a considerable market with manufacturers of high-grade wall papers, the luster obtained by the use of muscovite dust having the advantage of both permanency and brilliancy.

In an advance chapter from the "Mineral Resources of the United States, Calendar Year 1906," Douglas B. Sterrett, of the United States Geological Survey, reports the production of sheet mica in the United States for 1906 as 1,423,100 pounds, valued at $252,248, and of scrap mica as 1489 short tons, valued at $22,742. These figures show an increase over those for 1905 of 498,225 pounds in quantity and $91,516 in value for sheet mica, and of 363 tons in quantity and $4,886 in value for scrap mica. The eight States which shared this production are, in order of value of output, North Carolina, Colorado, New Hampshire, Virginia, Idaho, South Dakota, New Mexico, and Connecticut.

The imports of mica into the United States in 1906 were the largest ever recorded, the value being considerably more than twice as great as in 1902 and 1905, the years that formerly held the record. According to Mr. Sterrett, the total quantity imported and entered for consumption in 1906 amounted to 3,066,738 pounds, valued at $1,042,608.

The total production and consumption of sheet mica in the United States in 1906 was 4,489,838 pounds, as against 2,519,445 pounds in 1905, an increase of about 78 per cent. A comparison of the import figures with those of the home production shows that there is a wide field for the extension of the industry in the United States, and indeed the industry is expanding rapidly to meet the demand. Deposits carrying mica in commercial size are found in many parts of the United States from the Atlantic coast to the Pacific, and new developments are reported each year. Alabama and Georgia will probably appear in the list of producing States in 1907, and other States will doubtless show large gains in production.

Mr. Sterrett's paper, which is ready for distribution and may be obtained by applying to the Director of the United States Geological Survey, at Washington, D. C., contains much interesting and valuable information concerning the material and the methods of mining and manufacturing it, and includes a list of publications dealing with the subject.

QUARTZ (FLINT) AND FELDSPAR PRODUCTION IN 1906.

Quartz, the most abundant of all the minerals, occurs in so great variety of form and is utilized commercially in so many different ways that the statistics of its annual production prepared by the United States Geological Survey are comprised under several heads. Certain transparent, colored varieties of the mineral, such as rose and smoky quartz and amethystine quartz, have a gem value and are discussed in connection with precious stones; sand used for building, molding, and in pottery manufacture is separately treated, as are also sandstone and quartzite used for building purposes, although all of these materials consist of nearly pure quartz. The massive crystalline quartz, often called vein quartz, with flint and with quartzite, used for other than building purposes, and the associated and widely distributed feldspar deposits are grouped together and are discussed in an advance chapter from the report on "Mineral Resources of the United States, Calendar Year 1906." This chapter, prepared by Edson S. Bastin, is now ready for distribution.

The varieties of quartz dealt with in Mr. Bastian's report have a wide range of uses. Massive crystalline (vein) quartz is produced in Connecticut, New York, Maryland, and Virginia. That from the last-named State is used in the manufacture of metallic silicon and ferro-silicon by electrolytic processes, these materials being largely employed in steel manufacture to increase the toughness of the product. A large proportion of the quartz from New York. Connecticut and Maryland is ground and utilized in the manufacture of a wood filler. Massive quartz in blocks is used in the chemical industry as a filler for acid towers and to some extent as a flux for smelting copper; ground, it is used extensively in the manufacture of sandpaper, sand belts, scouring soaps, and polishes as a scouring agent in sand-blast apparatus, and in filters, and some of the finest grades are used by the dentists as cleaners. So far as known very little domestic flint has ever been commercially utilized, although its quality appears to be equal to that of the imported flint, which is brought in cheaply as ballast from France, Greenland. Norway, and England, and much of which is burned in kilns and ground for use in the pottery trade. Vein quartz is also used by pottery manufacturers.

According to Mr. Bastian, the production of quartz in the United States in 1906 amounted to 41,314 short tons of the crude material, valued at $37,632, and 25,383 short tons of ground quartz, valued at $205,380; a total of 66,697 short tons, valued at $243,012. These figures do not represent the entire amount of quartz and flint consumed for the year, for flint is imported to the value of $272,607.

The commercial fieldspar produced in the United States occur usually as constituents of pegmatites, and to meet the needs of the pottery manufacturers, by whom they are chiefly used, they must contain from 15 to 20 per cent. of free quartz. The material is used principally as a constituent of both body and glaze in true porcelain, white ware, and vitrified sanitary ware, and as a constituent of the slip (underglaze) and glaze in the so-called "porcelain" sanitary wares and enameled brick. At present it is quarried in Maine, New York, Connecticut, Pennsylvania, Maryland, Texas, and

Minnesota, and the total production in 1906 amounted to 39,976 short tons of crude feldspar valued at $132,643, and 32,680 short tons of ground feldspar valued at $268,888; a total production of 72,656 short tons, valued at $401,531. The use of the mineral is increasing and the domestic supply is supplemented by large importations from Ontario, Canada.

Book Notices.

Elements of General Chemistry with experiments, by John H. Long. 4th edition, revised and enlarged. 443 pages illustrations, 12-mo Philadelphia, B. Blakiston's Son & Co., 1906. Price, cloth, $1.50.

This work first appeared in the year 1898. The present edition is brought up to date and includes a chapter on the theories of solution and the conditions of chemical equilibrium. There are one hundred and seventy-five experiments in all fields of chemistry, interspersed with much information of value to beginners in the study of the science. R.

A Text-Book of Elementary Analytical Chemistry, qualitative and volumetric, by John K. Long. Third edition, revised and enlarged. 299 pages, illustrations, 12-mo. Philadelphia, P. Blakiston's Son & Co., 1906. Price, cloth, $1.25.

The present volume is intended for students who have gone through the work on general chemistry by Prof. Long. The author has arranged his course to meet the special needs of the students in the chemical laboratories of the Northwestern University Medical School, at Chicago. The book is uniform in appearance and size with the one previously noted.

R.

Wellcome's Photographic Exposure Record and Diary. United States Edition. 1907. 260 pages, illustrations, plates, 24-mo. New York, Burroughs, Wellcome & Co. Price, 50 cents.

This annual contains considerable information which will be useful to the amateur photographer. It deals with developers and development, restrainers, fixing and hardening, and other matters of importance in the photographic laboratory. The leading feature of the book is the exposure calculator which is attached to the back cover. It is a movable disc, by means of which the approximate exposure can be ascertained for any subject or plate. A dozen pages are devoted to light values of the different months, and a table gives the speed of about two hundred makes of plates and films. In addition to the blank pages for the diary there are also a number of pages carefully ruled for the purpose of recording negative exposures and positive exposures. The work is issued in pocket-book form and is adorned with several half-tone reproductions of photographs.

R.

Elementary Practical Chemistry. Part II. Analytical Chemistry. Qualitative and Quantitative. By Frank Clowes and J. Bernard Coleman. Fifth edition. 237 pages, illustrations, 12-mo. London, J. & A. Churchill,

1907. On sale in Philadelphia at P. Blackiston's Son & Co. Price, cloth, $1.00.

In the revision of this work additions have been made to the volumetric and gravimetric portions, and a new section on inorganic preparations has been added. R.

Principles of Qualitative Analysis from the Standpoint of the Theory of Electrolytic Dissociation and the Law of Mass Action. By William Böttger, translated with the author's sanction and revised with his coöperation by William Gabb Smeaton. 300 pages, illustrations, 8-vo. Philadelphia, P. Blakiston's Son & Co., 1906. Price, cloth, $2.00.

This text-book introduces modern conceptions into the teaching of qualitative analysis. Part I is devoted to testing a solution for metals; Part II, testing a solution for anions; Part III, the complete analysis of a given unknown; Part IV, the rare elements. There are analytical tables, including tests for cathions and anions and preliminary tests and methods of bringing solids into solutions. R.

Construction des Induits a Courant Continu L'Arbre et ses tourillons par E. J. Brunswick et M. Aliamet. 172 pages, illustrations, 12-mo. Paris, Gauthier-Villars, n. d. Price, paper, 2 francs, 50 c.; cloth, 3 francs.

Commutatrices et Transformateurs Electriques Tourants par Jean Paraf. 194 pages, illustrations, 12-mo. Paris, Gauthier-Villars, n. d. Price, paper, 2 francs, 50 c.; cloth, 3 francs.

These recent additions to the Encyclopédie Scientifique des Aide-Mémoire will appeal especially to the electrical engineer. Any one having a knowledge of French will find this series extremely useful.

R.

L'Annee Technique, 1906, par A. Da Cunha. Préface de Alfred Picard. 237 pages, illustrations, 4to. Paris, Gauthier-Villars, 1906. Price, paper, 3 francs, 50 c.

The leading article in this technical review of the past year relates to inventions and devices for the protection of the lives and limbs of workmen. There is also considerable space given over to the subject of heating and the distribution of water in houses. Thirty pages are devoted to a review of the work done in civil engineering and these are followed by a report on recent advances in locomotion, including automobiles. The volume is made up with the same care as heretofore.

Missouri Bureau of Geology and Mines. The quarrying industry of Missouri. By E. R. Buckley and H. A. Buehler. Forming Volume II, Second Series of the reports. 371 pages, illustrations, plates, maps, 4to. Jefferson City, State Printers, 1904.

This is a comprehensive report on the quarries of the State and their products, with a brief geological history. It deals with the uses and properties of building stones and the composition of rocks and rock structures. The chapter devoted to laboratory tests contains much interesting information on the strength of stones and the effect of thawing and freezing. R.

Thermodynamik technischer Gasreaktionen. Sieben Vorlesungen von Dr. F. Haber a. o. Professor an der Technischen Hochschule Karlsruhe i. B. 296 pages, illustrations, 8-vo. München, R. Oldenburg, 1905. Price, cloth, 10 marks.

These lectures were delivered before advanced students and colleagues of the author. The work treats of the practical and not the theoretical side of the question; it is intended to serve as a work of instruction and as an aid in the experimental investigation in the field of technical gas reactions and forms a supplement to the literature on the subject in the various technical periodicals. It is not a complete reference book but simply a guide, dealing with the salient points.

The work is carefully done and there are many references to the labor of others in this field. R.

Hypochlorite und Elektrische Bleiche. Technisch-Konstruktiver Teil von Viktor Engelhardt. 275 pages, illustrations, 8-vo. Halle a. S., Wilhelm Knapp, 1903. Price, paper, 12 marks.

Die Elekrolytische Raffination des Kupfers von Titus Ulke, Ins Deutsche übertragen von Viktor Engelhardt. 152 pages, illustrations, plates, 8-vo. Halle a. S., Wilhelm Knapp, 1904. Price, paper, 8 marks.

Elektrolytisches Verfahren zur Herstellung parabolischer Spiegel von Sherard Cowper-Coles. Ins Deutsche übertragen von Dr. Emil Abel. 17 pages, illustrations, 8-vo. Halle a. S., Wilhelm Knapp, 1904. Price, paper, 1 mark.

Künstlicher Graphit von Francis A. J. Fitzgerald, Ins Deutsche übertragen von Dr. Max Huth. 60 pages, illustrations, 8-vo. Halle a. S., Wilhelm Knapp, 1904. Price, paper, 3 marks.

Die Elektrolyse geschmolzener Salze. Erster Teil: Verbindungen und Elemente von Richard Lorenz. 217 pages, illustrations, 8-vo. Halle a. S., Wilhelm Knapp, 1905. Price, paper, 8 marks.

Die Elektrolyse geschmolzener Salze. Zweiter Teil: Das Gesetz von Faraday; die Uberführung und Wanderung der Ionen; das Leitvermögen von Richard Lorenz. 257 pages, illustrations, 8-vo. Halle a. S., Wilhelm Knapp, 1905. Price, paper, 8 marks.

Die Elektrolyse geschmolzener Salze. Dritter Teil: Elektromotorische Kräfte von Richard Lorenz. 322 pages, illustrations, 8-vo. Halle a. S., Wilhelm Knapp, 1906. Price, paper, 10 marks.

Elektrolytische Alkalichloridzerlegung mit flüssigen Metallkathoden von Dr. R. Lucion. 206 pages, illustrations, 8-vo. Halle a. S., Wilhelm Knapp, 1906. Price, paper, 9 marks.

Die elektrochemischen Deutschen Reichspatente. Auszüng aus den Patentschriften gesammelt, geordent und mit Hinweisen versehen von Dr. P. Frechland und Dr. P. Rehlander. 230 pages, illustrations, 8-vo. Halle a. S., Wilhelm Knapp, 1906. Price, paper, 10 marks.

Deutskhes Patentrecht für chemiker von Dr. Julius Ephraim. 608 pages, 8-vo. Halle a. S., Wilhelm Knapp, 1907. Price, paper, 18 marks..

Elektrometallurgie des Eisens von Dr. Bernhard Neumann. 176 pages, illustrations. 8-vo. Halle a. S., Wilhelm Knapp, 1907. Price, paper 7 marks.

Über die elektrolytische Gewinnung von Brom und Jod von Dr. Ing. Max Schlötter. 50 pages, illustrations, 8-vo. Halle a. S., Wilhelm Knapp, 1907. Price, paper, 2.40 marks.

The above are among the later issues of the series "Monographien über Angewandte Elektrochemie." The student of electro-chemistry will be most interested in the three volumes of Dr. Lorenz on the electrolysis of salts; the chemist with an inventive turn of mind will find much in Dr. Ephraim's work on the German patent laws and in the work on the electrochemical patents of Germany. Two volumes of the series are translations from the English, and it is hoped that some of the other issues may be translated into English for the benefit of those who are unable to make use of the works in the original. R.

Sections.

(Abstract of Proceedings.)

Mining and Metallurgical Section:—A stated meeting of the Section was held Thursday, October 3d, at 8 P.M.

In the absence of the President, Professor A. E. Outerbridge was called to the chair. Present, twenty-seven members.

The Chairman introduced Mr. E. G. Acheson, of Niagara Falls, N. Y., who presented the paper of the evening on Deflocculated Graphite.

The speaker illustrated his remarks by the exhibition of specimens which showed the peculiar properties of the new product.

The paper was discussed by Messrs. Carl Hering, C. J. Reed, H. F. Colvin, the Chairman, the author, and others. On Mr. Colvin's motion, duly seconded, a vote of thanks was passed to the speaker of the evening, and his paper was referred for publication. Adjourned.

W. J. Williams, *Sec'y pro tem.*

Electrical Section:—Stated meeting held Thursday, October 10, 8 P.M. Mr. Thomas Spencer in the chair. Present, forty-five members.

The paper of the evening was presented by Dr. Joseph W. Richards, of Lehigh University. Subject: The Electro-Thermic Production of Iron and Steel. The speaker introduced his remarks by reference to the rapidly growing importance of the subject, and called special attention to two recent official reports made by a special technical commission appointed to investigate the subject, by the Canadian Government.

The speaker described the present state of the art, with special consideration of the electric production of steel, the reduction of iron direct from the ore, and the production of ferro-alloys of the rare metals, tungsten, molybdenum, vanadium, etc.

The construction and mode of operation of the several types of electric furnaces were described and illustrated by means of lantern views.

In his comments on the various aspects of the industry, Dr. Richards declared his belief that the electro-thermic methods had so far progressed as to make it practically sure that the crucible steel process was doomed to early extinction; also, that the commercially economical production of iron direct from the ore, was now assured in a number of localities, such as Norway, Canada, and elsewhere, where cheap electric power could be depended on; and that a highly important branch of the art—the production of ferro-alloys, had already attained the dignity of an established industry.

The paper was discussed by Messrs. Outerbridge, Garrison, Conrad, Wahl, Colvin, Goldsmith, Loss, Hering, the chairman and the speaker.

At the close of the discussion, on motion of Mr. H. V. Loss, duly seconded, Dr. Richards was accorded a vote of thanks for his interesting and instructive remarks, and his paper was referred to the Committee on Publication. Adjourned.

RICHARD L. BINDER, *Secretary.*

SECTION OF PHYSICS AND CHEMISTRY.—Stated meeting held Thursday, October 17, 8 P.M. Dr. Rob't H. Bradbury in the chair. Present, forty-two members.

After the transaction of the formal business of the meeting, the President introduced the speakers of the evening.

Dr. Edward Goldsmith read a paper entitled, "The Jerseyite," describing a meteoric stone which recently had been observed to fall in the neighborhood of Gloucester, N. J. The paper will be found in the *Journal.* It was discussed by Dr. Wahl and the author.

Mr. Lowndes Taylor, of West Chester, Pa., a member of the Section, exhibited and described an Original Form of "Platting Range Finder."

Dr. Henry Emerson Wetherill exhibited and described a number of improved instruments for navigation, which, on motion, were referred to the Committee on Science and the Arts for investigation and report. Adjourned.

EDWARD A. PARTRIDGE, *Secretary.*

Committee on Science and the Arts.

(Abstract of proceedings of the stated meeting held Wednesday, October 2d, 1907.)

DR. WM. O. GRIGGS in the chair.

The undermentioned reports were adopted:

(No. 2392.) *Improvements in Diffraction Color Photographs.* Herbert E. Ives, Weehawken, N. J.

ABSTRACT:—The subject of this investigation is an application of the well-known three-color method of reproducing color and combinations of colors by photography, and is, essentially, an improvement on a process

invented by Prof. R. W. Wood, now of Johns-Hopkins University, Baltimore, Md.

The invention is covered by U. S. Letters Patent No. 817,569, filed October 19, 1905, and granted April 10, 1906. Mr. Ives has fully described his inventions in a paper read before the Institute, which may be found in the *Journal* for June, 1906, page 439, *et seq.*

In diffraction color photographs the colors are produced by three superposed or mixed diffraction grating images, each grating providing, by a suitable disposition of viewing apparatus, one of the three primary colors.

The diffraction color photographs made by Prof. Wood had the diffraction-grating images superposed on the same plate, or on two or three plates in register. Prof. Wood in a paper read by him before the British Association, and published in Nature (Vol. lxx, page 614, 1904), called attention to the fact that in practice the superposing of the lines of the diffraction grating tended to produce additional disturbing effects, or false colors, by the rearrangement of the superposed lines giving spectra that were out of harmony with those of the normal diffraction gratings.

Even a modification of the Joly process, that was tried by Prof. Wood, did not give uniformly satisfactory results, largely, perhaps because of the difficulty of securing perfectly satisfactory Joly pigment screens, and also because of the occasional occurrence of secondary diffraction grating lines with the lines of the Joly screen.

To overcome these objections Mr. Ives makes use of continuous glass gratings, such as are usually employed in making diffraction gratings, but prints through a screen with alternate opaque and transparent spaces being twice the width of the transparent ones.

As a fourth modification of the original method, Mr. Ives has been able to practically apply a suggestion made by Mr. Thorp, of Manchester, England, in 1900, and produce all of the necessary color by the use of a single diffraction grating rotated to different angles. * * * * The resulting picture constitutes a refraction color photograph composed of juxtaposed lines or strips of diffraction lines, the lines of each strip being spaced differently from those of the other strips. When viewed in the special device designed by Mr. F. E. Ives, the pictures thus prepared are highly satisfactory and reproduce the original colors in a manner that approximates very well the results that have been obtained with the Chromoscope.

The report recommends, in conclusion, for the ingenuity and originality displayed in the invention, the award to Herbert E. Ives of the Edward Longstreth Medal of Merit. *(Sub-Committee:*—M. I. Wilbert, Chairman; A. W. Goodspeed, J. W. Ridpath.)

(No. 2404.) *Electric Furnace for the Production of Carbon Bi-Sulphide.* Edward R. Taylor, Penn Yan, N. Y.

This is reserved for publication in full. The report awards the Elliott Cresson Medal to the inventor. *(Sub-Committee:*—Jos. W. Richards, Chairman; Carl Hering, S. S. Sadtler.)

(No. 2408.) *Pressed Steel Pulleys.* Ferdinand Philips, Philadelphia, Pa.

This report is reserved for publication in full. The report awards the Elliott Cresson Medal to the inventor. *(Sub-Committee:*—Hugo Bilgram, Chairman; Kern Dodge, J. Y. McConnell.)

(No. 2409.) *Diffraction Color Photographs and Process of Making Same.* Prof. R. W. Wood, Johns-Hopkins University, Baltimore, Md.

ABSTRACT:—The invention of Prof. Wood is covered by U. S. Letters Patent No. 755,983, dated March 29.

This process depends on the production of color sensations by diffraction gratings of varying grating spaces placed between the eye of the observer and the source of light.

Prof. Wood described his invention in a paper entitled, "An application of the Diffraction Grating to Color Photography," published in the Philosophical Magazine for April, 1899. Further details of the process were subsequently published in Nature, in the Journal of the Society of Arts, London, and in other scientific journals. The process depends on the bending of the rays of light, by diffraction gratings of varying fineness. The diffraction gratings used for this purpose are of glass ruled with fine parallel lines—several thousand to the linear inch. When a fine point or line of light is viewed through such a plate or diffraction grating there will be seen spread to either side of the source of light or central image, a series of spectra beginning with red at the furthest or extreme end of the visible spectrum. By the use of a coarser or finer grating these spectra can be displayed nearer or farther from the central image at will and the several portions can thus be made to be superposed at one given point.

Prof. Wood's patent is for the finished photograph and for a method of producing multi-colored photographs by superposing monochrome records of multi-colored objects made through properly selected color screens and photographing them in accurate register through suitable diffraction gratings adapted to produce, at a given point, the color corresponding to that of the color screen.

The pictures themselves are produced by using positives, such as those made by Mr. Ives for his Chromoscope. and printing, on a sheet of thin glass flowed with a solution of bichromated gelatine, successively the red, the green and the blue record positive through the corresponding diffraction grating.

The method followed by Prof. Wood is described at some length in the Journal of the Society of Arts, London, for February, 1900, page 287. The completed picture is described as "A photograph consisting of a surface having superposed diffraction rulings of different spacing, each spacing of diffraction ruling being adapted to produce a different color.

The patent granted to the inventor appears to cover the fundamental principles applied to the reproduction of color in photographs by the diffraction process and the practical results that he has shown appear to indicate that he has been able to secure satisfactory and highly interesting pictures.

In recognition of the thought and originality displayed by Prof. Wood in the production and in the subsequent development of diffraction color

photographs and the method of making them, the report recommends the award of the John Scott Legacy Premium and Medal to the inventor. *(Sub-Committee:*—Martin I. Wilbert, Chairman; A. W. Goodspeed, J. W. Ridpath.)

The following report passed first reading:

(No. 2411.) *Diffraction Chromoscope.* Frederic E. Ives, New York, N. Y.

PROTESTS against the following reports were received and considered, and the subjects were referred back to their respective Committees:

(No. 2400.) *Primary Battery.* Frank A. Decker, Philadelphia, Pa.

(No. 2401.) *Electrical Pyrometer (LeChatelier).* W. C. Heraeus.

NEW BUSINESS:—Report No. 2389—*Townsend's Thermometer Support,* adopted March 6th, 1907, was made the subject of a motion by Dr. Williams, duly seconded, directing a reconsideration of the Committee's action.

Adjourned.

LOUIS E. LEVY, *Sec'y pro tem.*

The Franklin Institute.

(Proceedings of the stated meeting held Wednesday, October 16th, 1907.)

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, PA., October 16, 1907.

DR. EDWARD GOLDSMITH in the chair.

Present, forty-two members and visitors.

Additions to membership since last report, four.

After the transaction of the usual formal business, the chairman introduced Prof. Oscar C. S. Carter, of the Central High School, who presented a communication entitled, "Camden's Water Supply is not Derived from the Delaware River by Infiltration."

The speaker illustrated his address with the aid of charts and lantern photographs.

The paper, giving the author's proofs of his thesis, appears in the *Journal* for November, 1907.

After a full discussion of the subject the thanks of the meeting were voted to the speaker of the evening. Adjourned.

WM. H. WAHL, *Secretary.*

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FOR THE PROMOTION OF THE MECHANI C ARTS

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The Franklin Institute is not responsible for the statements and opinions advanced by contributors to the *Journal.*

THE FRANKLIN INSTITUTE.

(Stated meeting held Wednesday, October 16. 1907.)

A New Form of Cooper Hewitt Mercury Vapor Lamp.*

BY F. H. VON KELLER.

Within the last few years such a wealth of information regarding Mercury Vapor apparatus has been published, that a general description of the interesting phenomena appearing in the Mercury Vapor Container would substantially prove a repetition of much that has been well said before. Nevertheless, it seems not out of place to turn attention to one specific technical application of the much discussed principles, embodying some of the most interesting features: a new form of lamp, developed and now commercially employed by the Cooper Hewitt Electric Company of New York To qualify the adjective "new": while the form of this lamp is entirely novel, its operation is based on principles which have previously been employed by the company. This lamp differs from other types of Mercury Vapor lamps principally in its structure and the means for starting the arc in the lamp. Inasmuch, however, as the starting method is a

*Read by title.

factor determining the whole design and layout of a lamp, the one under discussion has assumed a shape differing from other types in more than this one respect.

As well known, the starting of Mercury Vapor lamps offers to the engineer a problem in itself. For, unlike for instance the filament of an Incandescent Lamp, the inert vapor separating the two electrodes of a Mercury Vapor lamp is by no means a conductor of electricity. To render this vapor conducting, such as it is to a very high degree in the running lamp, it is necessary to start and maintain by virtue of the electric current the vaporization of the mercury at the negative electrode.

Thus we encounter an apparent resistance to starting, whose main seat seems to lie in the negative mercury-electrode. To overcome this resistance to starting we can, broadly speaking, employ either one of two methods.

(a) Either break down the negative electrode resistance by means of a relatively high voltage, thereby paving the way for the operating voltage to establish and maintain the flow of current in the lamp,

(b) Or establish current in the negative electrode by breaking its contact to another electrode in the main or in a supplementary circuit.

I. STARTING METHODS.

Assuming that the reader is familiar with the general form of the Mercury Vapor lamp, the following recapitulation will briefly describe a few of the more prominent starting-methods which are being employed in practice:

(a) *Contact-Method.*

The fluid mercury is caused to momentarily form a connecting bridge between the two operating electrodes. When this bridge severs, the flow of current starts. This method is represented by the so-called "Tilting Lamp," where the tube is tilted by hand or automatically by means of a solenoid, thereby causing the mercury to flow from end to end of the tube and to make and break connection between the two operating electrodes. After the current-flow is thus started on the up-tilt of the tube, the same on the down-tilt falls back into its original position by gravity. This

method of starting is by far the simplest in principle, and has proven to be extremely reliable in operation. By this method can be started any tube which will run successfully.* The starting therefore is not sensitive to vacuum conditions. Tilting lamps are widely employed and a representative type is shown in accompanying cut, Figure 1. The lamp-tube of this method in itself is simple, easily manufactured, and easily shipped.

(b) *Filament Method.*

Here the tube itself is stationary, while contact between the negative electrode and the filament is made and broken by means of moving parts placed inside the tube. The filament is a thin carbon rod of high resistance, connecting to and extending from the positive electrode (usually iron, nickel or graphite) down into the vicinity of the negative mercury-electrode. When the voltage is thrown on the lamp, a small current passes from the positive terminal of the tube through the filament to the mercury and the negative terminal. Now this current by magnetizing a solenoid, either raises the filament or lowers the mercury level. thus breaking the contact at the mercury-surface and starting the flow of current between the negative electrode and the filament. The current thus started then climbs along the high resistance filament to the positive electrode, shunting the filament and leaving it to conduct only a negligable amount of current while the lamp is in operation.

Tubes started by this method naturally assume a more complicated form. Their manufacture is delicate and expensive, and the shipping becomes a serious question. Moreover, the starting is sensitive to vacuum conditions prevailing in the tube. Lamps started by this method have not come into the market to any considerable extent. owing undoubtedly to the difficulties inherent to the tube design.

(c) *High Voltage Kick Method.*

Here a comparatively high voltage kick is impressed across the tube-terminals to break down the initial resistance and effect the

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*A tube whose vacuum is impaired, but not enough to interfere with successful running, may yet cause difficulty in starting by some methods. Not so, however, when employing the Contact-method.

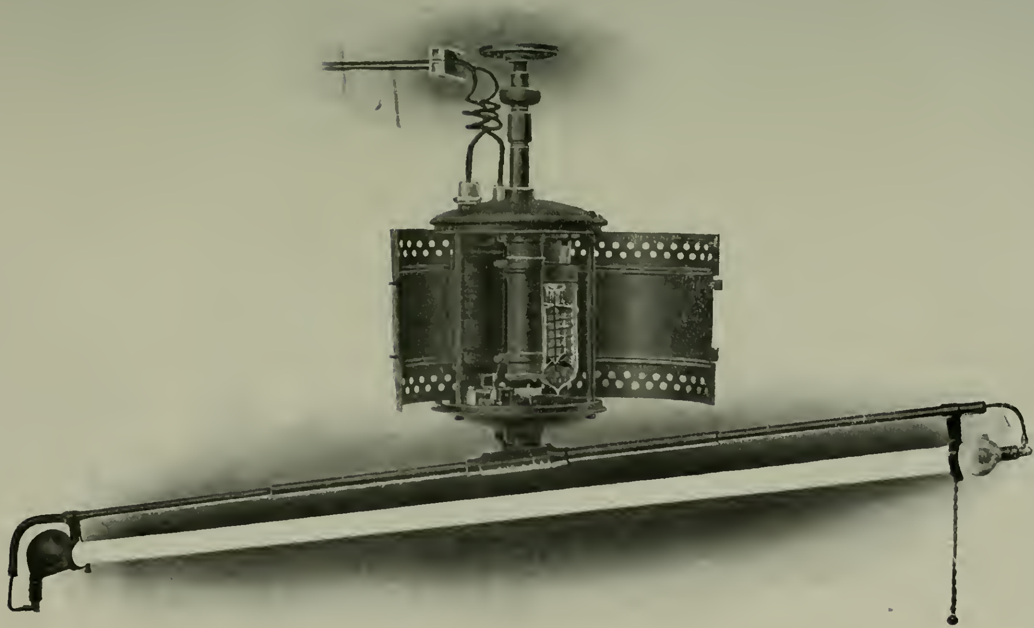
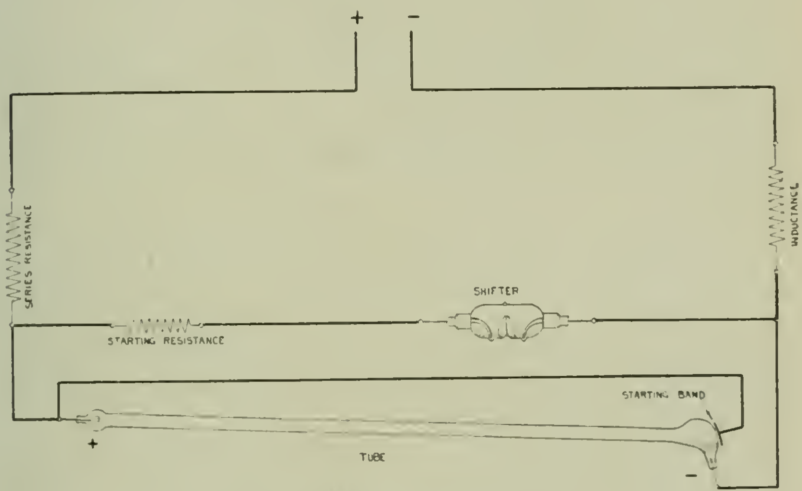


Fig. 1. Tilting Lamp (tube 45 inches long).

starting. As the lamp under consideration employs this method of starting, a more detailed description of the method and the apparatus employed is given in the following:

A quick-break mercury-switch, the so-called "Shifter," is connected in series with the starting resistance across the tube-terminals (See Fig. 2.) When the lamp is switched on, the circuit is completed through the inductance-coil, the Shifter, the starting resistance and the series resistance. The inductance-coil being magnetized by the current, actuates an armature, which



G 2

CONNECTIONS OF AUTOMATIC LAMP

STARTED BY THE HIGH VOLTAGE KICK METHOD

now causes the Shifter to open this starting-circuit. The energy stored in the inductance thereby being forced to find a new discharge-path, now breaks down the initial resistance of the tube, and effects the lighting. The so-called "Starting-band," a metallic coat painted on the outside of the enlarged bulb at the negative end of the lamp, (Condensing Chamber) forms one side of a condenser, the other side of which is the mercury-electrode, the glass serving as dielectric. The Starting-band is connected to the positive terminal and the high voltage which is impressed upon this condenser during the action of the Shifter facilitates the starting.

II. NATURE OF THE INITIAL LAMP RESISTANCE.

We have in the introductory remarks already made reference to the nature of this initial resistance. Therefrom it was apparent that a peculiar excitation of the mercury-electrode was necessary to render the vapor conducting. In all Mercury-Vapor apparatus the negative (mercury) electrode is destined to play a peculiar role. In the running lamp a small white spot of intense brilliancy can usually be observed traveling over the mercury surface in an erratic course and with great rapidity. At this point the current passes from the mercury into the vapor. At this point also takes place the production of the conducting mercury vapor. At this point—we must therefore expect—the greatest concentration of potential is required, to effect starting. Thus, in our lamp 75 to 90% of the total necessary starting-voltage is due to the negative electrode. The balance is required to break down the vapor-column. The positive electrode offers practically no initial resistance.

From 1,000 to 10,000 volts may be necessary to break down the initial resistance of the mercury-electrode, the actual amount being determined by the physical form of the mercury surface and the vacuum conditions in the tube. To hold this voltage at as low a value as possible two means are resorted to in the lamp under consideration:

(a) Upon the outside of the Condensing Chamber and opposite the mercury edge is painted a metallic coating, called the Starting-band (See above.) The same may conveniently extend $\frac{1}{2}''$ below and $1''$ above the inner mercury edge. When the high voltage kick takes place, minute sparks seem to jump from the mercury surface to the glass inside the bulb. As though these sparks had punctured a highly resisting film on the mercury surface, the main current now issues from one or several of these punctures. Thus the result obtained here is of a similar nature as that caused by the contact method, only of course, in this case of less effectiveness than in the Contact—or Filament—methods on account of the less electric energy spent in the discharge.

The Starting-band is a most powerful factor in reducing the initial resistance. The necessary voltage is thereby decreased by approximately 1000 to 3000 volts.

(b) As is well known, mercury lying in a glass vessel will not

form a flat edge and adhere to the glass walls as water does, but the edge will appear round and the mercury will touch the glass walls at a level lower than the actual mercury-surface. Nor will clean mercury readily adhere to the glass. The exciting action taking place at the mercury edge, it appears that the resistance to starting is extremely sensitive to the geometrical form of this edge, in such a way that the usual round edge is productive of a high resistance, whereas a flattened edge will materially reduce the same. Fortunately the presence of a slight amount of amalgam, such as of Fe, Cu, Ag, Pt, Mg, Al (less than .01%) will produce a flat edge of the mercury, without impairing the vacuum of the tube. Incidentally this flat edge will usually take the current during running of the lamp, *i. e.*, the current instead of wandering about the mercury surface will now attach itself to the flat mercury edge, spreading in a thin bright streak over a length of ½ to 1 inch. This fact adds considerably to the stability of the lamp, which is thereby enabled to remain lighted on very much lower currents than when the current is wandering. By flattening the mercury edge or part of it by the addition of an amalgam to the mercury, the initial voltage required may be reduced by several thousand volts.

Besides the factors mentioned, the temperature of the mercury at the time of starting is also a determining factor. Generally speaking, the initial resistance of a hot electrode is less than that of a cold one. The presence of foreign gases in the tube will also effect the initial resistance of the negative electrode in such a way as to lower the same, i. e. the better the vacuum, the higher will be the initial resistance. In normal lamps of the type under discussion (using the Starting-band) the initial resistance of the negative electrode will rarely exceed 3000 volts.

In addition to the negative electrode, the vapor separating the two electrodes also offers a resistance to starting. The same increases with the length of tube and is quantitatively dependent upon the state of vacuum, *i. e.*, the presence of foreign gases, and the temperature of the lamp at the time of starting. The presence of foreign gases will usually increase the vapor resistance.*

*Nevertheless, this starting method is not sensitive to vacuum-conditions. In the presence of foreign gas in the tube the Shifter will "kick" a few times, each time causing a stronger flash in the tube, until there is sufficient mercury-vapor produced to maintain the arc.

III. THE LAMP TUBE.

The lamp tube consists of a glass tube 50″ long and 1″ in diameter (See Fig. 3), the one end of which joins the condensing chamber, the other the positive electrode chamber. The condensing chamber extends into a small cup into which is sealed a platinum wire serving as the negative terminal of the lamp and making connection to the mercury which lies in the condensing chamber. Upon this cup is cemented a terminal-cap connected to the platinum leading-in wire and serving as terminal for the outside connecting wire. The Starting-band painted upon the condensing chamber with aluminum paint makes connection to a suitable post which takes the outside connection. The positive electrode consists of an iron cup attached to a platinum wire, sealed into the glass. The positive end is also provided with a suitable terminal-cap.

The tube is exhausted under a high temperature and during the exhausting the iron electrode is treated, i. e. heated with electric current to a white heat. By this process are removed such gases occluded in the iron, as would be detrimental to the performance and life of the tube.

The tube has a voltage of about 70 to 75 volts across its terminals at the normal operating current of 3.5 amperes.

IV. THE SHIFTER AND THE HIGH VOLTAGE KICK.

The high voltage kick is effected by the action of the Shifter (Fig. 4.) The same consists of a small glass bulb $1\frac{1}{4}''$ in diameter and $2\frac{1}{4}''$ long, provided with a groove which partitions off the two puddles of mercury, serving as the two electrodes. To each one of these puddles leads a small platinum wire making connections to a suitable terminal-cap at each end of the Shifter. These caps also serve as pivoting points around which the Shifter revolves. The Shifter is exhausted to a high degree of vacuum similar to the tube.

When the current is thrown on the outfit, the mercury is lying in the bulb beyond the groove and can thus form a continuous bridge connecting the two leading-in wires together and closing the electric circuit. As the Shifter is turned in its pivots around its axis by the action of the magnet-armature, the groove cuts

Fig. 3. Automatic lamp, started by voltage-kick method (tube 50 inches long).

into the mercury bridge, dividing the mass of mercury into two separate puddles: the electrical connection is broken.

If it was of advantage in the tube to reduce the initial resistance to a minimum, in the Shifter it is the aim to make this resistance as high as possible. The same is therefore pumped to a

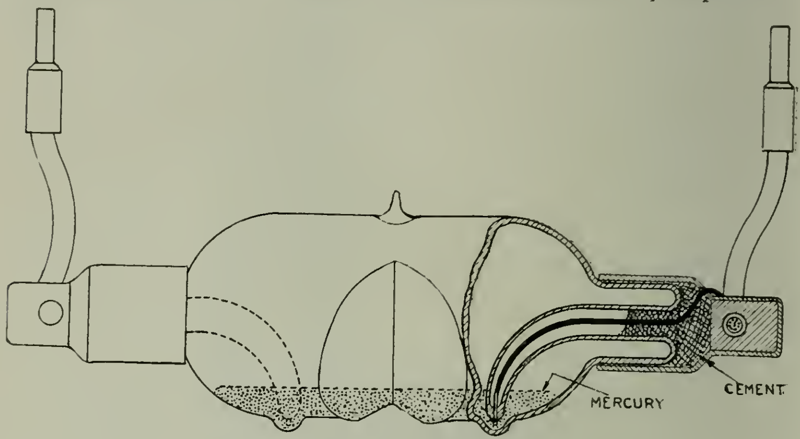
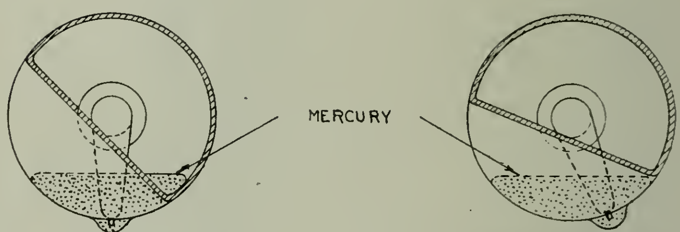


FIG. 4 SHIFTER



CONNECTION CLOSED CONNECTION OPEN

very high degree of vacuum and the mercury is kept as clean as possible.

When the mercury bridge severs the Shifter starts and remains running like a small Mercury Vapor lamp, started by the Contact-method. However, the current in the Shifter being limited by the starting-resistance to only 1 ampere, the Shifter will run (i. e. maintain the arc) only about $\frac{1}{4}$ of a second and then go out.

At this instant the initial resistance of the negative electrode of the Shifter re-establishes itself.

Generally speaking, the negative electrode of any Mercury Vapor apparatus will tend to re-establish its initial resistance while running on currents below four amperes. The frequency with which this will occur is a function of the current. To counteract this action in the running Mercury Vapor lamp an inductance is always inserted in the lamp-circuit, which reacts upon these impulses with a high voltage-kick and thus keeps the lamp running. In our lamp the same inductance which serves for starting also insures the stable running of the lamp at 3.5 amperes. This same inductance, however, will sustain our Shifter for only $\frac{1}{4}$ second at the low current of 1 ampere.

When the Shifter-current ceases, there takes place a shifting of the current from the Shifter to the tube. Hence the name "Shifter." To accomplish this shifting it is necessary that at the instant of current-interruption the initial resistance of the Shifter exceeds that of the tube. We see here an instance where the initial resistance of the Shifter with a separation of the electrodes of $\frac{1}{4}$ to $\frac{1}{2}$-inch exceeds that of the tube with a separation of electrodes of 50 inches. This demonstrates how the distance between electrodes (i. e. length of the vapor-column), when compared with the negative electrode, plays a negligable part with respect to the total initial resistance. The difference in initial resistance of tube and Shifter lies of course in the fact that the tube-resistance is artificially held low by Starting-band and flat mercury-edge, whereas that of the Shifter is held high by excellence of vacuum and the use of very clean mercury.

In interrupting the current in the inductance of our lamp, a voltage of about 4000 volts is thrown across the terminals of the tube. This is in practically all cases sufficient to break down the total initial resistance and effect the starting. The operating voltage can now send the normal current through the tube. This current keeps the inductance coils magnetized (See Fig. 2), and thus the Shifter is kept open, i. e. the starting-circuit remains interrupted.

V. AUXILIARY PARTS.

In cut Fig. 5 are shown the auxiliary parts of the lamp under discussion. Connections herein are made as per diagram Fig. 2.

Series- and starting-resistance are both wound upon a porcelain spool, coated with a vitreous enamel. On the series-resistance, (hidden in Fig. 5) connection can be made to either one or two points, thus making the outfit practicable for circuits of widely varying supply voltages. The tube itself

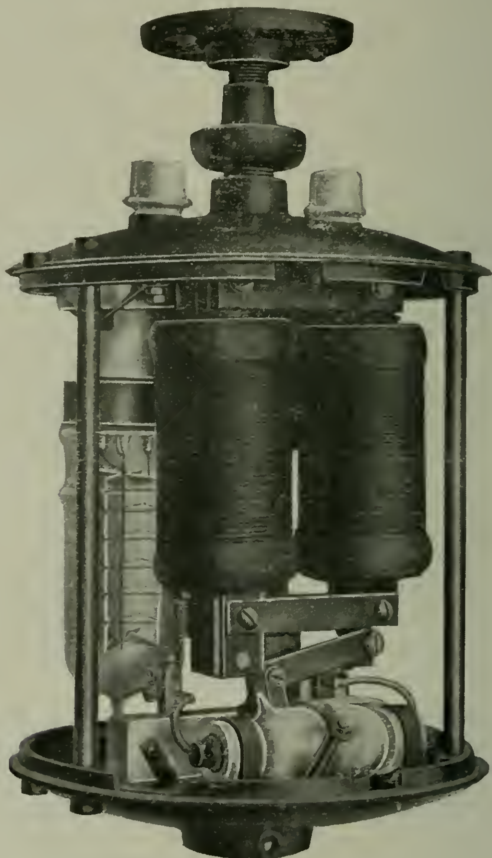


Fig. 5. Auxiliary parts of automatic lamp.

taking only seventy-two volts, the balance of the voltage (with the exception of the drop across the inductance coil) is taken up in the above mentioned series-resistance and in the so-called "Ballast." The latter is a resistance consisting of a fine iron wire and enclosed in a glass bulb containing hydrogen

at a low pressure.* The resistance of this wire rises rapidly with increasing current, due to the increasing value of the temperature-coefficient, as the iron wire approaches red-heat; in such a way that the drop across the Ballast is trebled, while the current increases by about 25%. In spite of the adverse voltage-characteristic of the tube the current is through the action of the Ballast held at a nearly constant value in the neighborhood of 3.5 amperes over a large range of supply-voltage. The lamp is thereby rendered extremely stable and very little sensitive to fluctuating line-voltages, so that the candle power (which is a function of the current) experiences only slight variations on unstable supply-circuits. The function of the inductance in series with the lamp has already been discussed under paragraph IV.

VI. LIGHT, EFFICIENCY AND LIFE.

The light emitted by the tube is of the greenish hue with which the public has become acquainted. While this color excludes the lamp from places where æsthetic considerations in the choice of illuminant are paramount, or where color values must be as true as possible, yet this very color has its virtues not to be underestimated. For the absence of red rays in the spectrum makes this light the least harmful to the eyes among all the illuminants known. Add to this fact the low intrinsic brilliancy of the light (5-6 C. P. per sq. in.), add the great diffusion and absence of shadows under the lamp, (characteristics which are inherent to the tube-form), and it is not surprising to find the Mercury Vapor Lamp holding a distinguished place among illuminants for its very quality of light.

The lamp under discussion gives a light of about 800 C. P. radial to the axis of the tube. Thus the efficiency of this lamp is about ½ Watt per C. P. The lamp is usually provided with a reflector. In the course of the lamp's life the C. P. decreases about 20%, due to the discoloration of the tube.

Fully of as great importance as any of the virtues enumerated stands out the remarkable record which the Mercury Vapor Lamp has established with respect to life. A tube may be said to live as long as its vacuum remains unimpaired. Within the tube,

*The Ballast-wire normally operates at a low red heat. The presence of hydrogen in the bulb from which the air is carefully exhausted, prevents oxidation of the wire and aids the dissipation of heat.

however, no progressive deterioration of vacuum takes place and it is only when the air gains access that a tube will fail. This is usually the result of a crack in the glass-structure, caused by handling or mishandling the tube, by the hammer of the mercury or strains in the glass. Without further analyzing these indefinite factors, a careful compilation of data obtained within the last three years shows an average life of 4000-5000 hours per tube, while tubes of 10,000 hours are by no means unusual. Actually there are a number of tubes in existence whose life exceeds 20,000 hours, and which are still intact.*

This means to the user of the lamp that during 4000-5000 hours any individual outfit requires practically no attention. Thus the cost of maintenance is reduced to a figure unequalled by any other type of lamp in existence.

VII. CONCLUSION.

The lamp described herein is started by essentially the same method as employed by Mr. Peter Cooper Hewitt before the Mercury Vapor Lamp had ever appeared before the public. The first lamps manufactured by the Cooper Hewitt Electric Company, more than five years ago, according to this method were non-automatic, the high voltage kick being produced by the action of a mechanical quick break oil-switch mounted on the wall and operated by hand. The tube was stationary and of a similar construction as the present one, employing the Starting-band. Auxiliary parts were separately mounted on wall or ceiling in the vicinity of the lamp.

The method of starting by tilting has proven entirely satisfactory and has gone largely into use, but as the field of the Mercury Vapor Lamp grew the demand for a simple form or stationary automatic type has made itself more and more felt. As a result of this commercial demand the type herein described has been developed.

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*The figures given are based upon performances of Tilting-lamps. The lamp under discussion not being placed upon the market until recently it was impossible to give representative life-data for this lamp. Evidence tends to show, however, that this type will prove even superior with respect to life on account of the total absence of motion in the tube. The moving mercury of the Tilting-lamp is undoubtedly responsible for many of the cracks in the glass-structure.

Diamond Mining.

(Abstract of a lecture delivered before the Franklin Institute, Friday, Nov. 15, 1907.)

By Henry Leffmann.

The diamond has been for many centuries the most precious stone. It owes its prominence to an association of several peculiarities, among which are rarity, hardness and exceptional optical properties. Notwithstanding the comparative ease and certainty with which it can now be distinguished from other stones, it is not sure that in ancient times such distinction was appreciated. It is not unlikely that quartz, zircon, tourmalin and other brilliant crystals were confused with each other and with the diamond. The Greek word "adamas," cognate with our word "diamond," means "unconquerable," and was applied to steel as well as other hard materials. No diamond is known the history of which goes back to pre-Christian times. The oldest was in the mantle of Karl, king of the Franks, better known as Charlemagne, who was crowned Emperor of the Romans in St. Peter's, Rome, on Christmas, A.D. 800. The fact that the territory occupied by the Egyptian and Roman empires does not include important diamond-bearing districts, probably accounts for the gem not appearing prominently in the literature of those nations.

While diamonds may be found in many places, and in many geological formations, the valuable mines are few. For many years India was an important source, but it is interesting to note that Golconda, a name that has been so long closely associated with the gem, is not a mine-locality at all, but a market-town, at which diamonds and other valuable articles were bought and sold. The diamond mines of Southeast Brazil, in the province of Minas Geraes (General mines) have yielded many fine stones, but are now of minor importance, though they have furnished in one year about 40,000 karats (nearly twenty avoirdupois pounds). Diamonds from these older localities have of recent years been termed "old mine stones," and it is probable that most of the gems of this class that now appear in the market are from stocks that have long been in private hands.

Geologists and mineralogists have long been much interested in the genesis of the diamond, and many theories have been put forth. The stone rarely occurs in the place of its formation, hence a study of its surroundings may not assist in solving the problem. Itacolumite has been supposed to be the matrix of the diamond, but this view is not now generally accepted. It is supposed that some light on the formation is thrown by the experiments of Moissan, who found that if iron highly charged with carbon is allowed to cool rapidly under great pressure, minute carbon crystals, having many of the characters of the diamond, are found intermixed with the iron-mass. It has also been supposed that the decomposition of carbon dioxide, or of some hydrocarbons under great pressure, might give rise to the gem, but the conditions in nature do not seem to justify assuming these different actions, or any that have a close analogy to them.

Newton was the first to suggest that the diamond has a relation to organic rather than inorganic matter. He based his opinion on the resemblance between certain optical properties of the gem and those of some hydrocarbons, such as turpentine. Of course, he did not know the formula of any of these, but he knew their organic origin. It seems to me, however, that Newton's view was rather a lucky hit than a logical deduction. In the last decade of the 17th century, about the time that a visitor to Philadelphia was writing to a friend concerning the fine forest that stretched from 4th street to the Schuylkill, two Italian investigators, Averami and Targioni, working under the patronage of the Grand Duke of Tuscany, succeeded in burning a diamond by the aid of a lens.

In 1867, a resident of one of the Boer villages, on the Orange River, South Africa, was attracted by the luster of a stone that a child had found on the river bank. It was ultimately sent to Dr. Atherston, an expert mineralogist, at the English settlement near Cape of Good Hope. He pronounced it a diamond, and fixed a value of $500, which was afterward obtained for it. It weighed 23.5 karats. Further search at the suggestion of the expert failed to discover another diamond until some months had elapsed. The fact that diamonds could be obtained attracted at once, of course, many seekers. For some time the workings were entirely along the banks of the Orange River and its tributaries, especially the Vaal.

After some years of this method of mining, an important discovery was made of a diamond-yielding deposit far from the alluvial soil, which, until then, had been supposed to be exclusively valuable. On the Jaegersfontein farm, in the Orange Free State, southeast of the Vaal River, the frequent occurrence of garnets was noted, and as it had become a belief that garnets are indicative of the diamond, in that part of the world, the overseer of the farm prospected, and a few feet below the surface found a valuable stone. This was the first of the so-called "dry mines," now the feature of South African diamond mining. It is not necessary to give the details of the discovery of the other mines. The most important are in the neighborhood of Kimberly, and are controlled by the De Beers Consolidated Mines, Ltd. Several important mines are not directly controlled by this syndicate. Among these are the Jaegersfontein mine, in the Orange River Colony, about eight miles southeast of Kimberly, and the Transvaal mines, southwest of Pretoria. Even these mines are, however, apparently in a "gentlemen's agreement" with the main company to prevent competition.

The geology of these districts has naturally attracted great attention, but the location is so far out of the line of ordinary travel that but comparatively few have studied it. Passing over the discussions as to the surface geology, now considered by most authorities to be of glacial origin, it is found that the diamond mines are a more or less decomposed mass of rocks filling the craters of volcanoes. These craters are locally termed "pipes." They are at most only a few acres in area, but extend to unknown depths. One of them is now mined at more than two thousand feet below the surface. The mines of the De Beers Company, by far the largest operators, are included within the limits of a parallelogram about eight miles long by six broad, within which five mines are located: DeBeers, Kimberly, Dutoits Pan, Bultfontein, and Wesselton (formerly Premier).

The methods of obtaining diamonds at the mines are entirely different from the old methods, when river gravels were washed by hand. A large amount of intricate machinery has been installed, and some methods have been adopted that have been rendered necessary by the peculiar nature of the product. To understand the principal points it will be necessary to consider the character of the material from which the stone is obtained. The mass

of partly decomposed rock filling the "pipe" is commonly known as "blue ground," from the prevailing color. There is, however, some material termed "yellow ground." The material is sometimes soft enough to break easily, but is usually hard.

When the mines were first opened the work was entirely at the surface, under many claims of small area. The miner simply dug, broke and sifted the earth. This soon led to excavations that interfered with one another and caused accidents by falling earth. Attempt was made by the local government to restrain the excavations, but it was unsuccessful. When a given "pipe" passed under one control, the excavation was simple; the material was taken out regularly. Even this method became unsatisfactory. The deep narrow funnel was liable to accidents and interferences. The present system is largely by shafts sunk in the adjacent hard rocks with lateral galleries at levels of about thirty feet. The following is the order of rock found in the sinking of the side shafts of the De Beers mine: Red soil (decomposed basalt), 20 to 30 feet; black shale, with much free carbon and pyrites, 200 to 300 feet; thin conglomerate, probably glacial, 10 feet; hard amygdaloid (olivin-diabase) 400 feet; quartzite, 700 feet. Quartz porphyry penetrated 1000 feet, and not passed.

The principal minerals found in the blue-ground are olivine, pyroxene, mica and garnet. Serpentine, as a product of alteration, is found in rock fragments.

Although the blue ground is quite hard when mined, it becomes by long weathering friable, and the gems can be obtained by washing. To secure this weathering large storage areas, termed "depositing floors," are provided. One of these, within the De Beers district, is four miles long by half a mile broad, and two others are nearly as large. The floors are surrounded by a fence and guarded, for the material has to lie about a year before it is washed. The washing is conducted by elaborate washing machines, which clear out the looser matter but leave the diamonds mixed with crystals, *e.g.*, garnets and zircons, of little value. For a long while these were sorted out by hand, but it has been discovered that wet diamonds will stick to a greasy cloth, while many other hard minerals will not stick. The separation of the precious stone is, therefore, easily secured by passing the mixture over screens of greasy cloth. The grease is, from time to time, cleaned of diamonds, and is itself occasionally renewed. After

the diamonds are obtained, they must be sorted according to standards of quality. This is done by a few trained workers, who make up packages of different grades and deliver to the business department.

The mining and rough work of the district is mostly done by native (black) labor. Diamond mining differs from all other mining in the ease with which valuable material may be secreted, hence one of the most difficult problems in South Africa has been to prevent the surreptitious removal of the rough stones. A special system has been inaugurated. A native applying for work must sign a contract for a specific time, agreeing to live in an enclosure, called a "compound," until the time has expired. A compound is about four acres in area, and is provided with comfortable living quarters, swimming pool, exercise grounds, medical attendance, and in general, conditions that allow a reasonable degree of comfort. The area is surrounded by a fence of corrugated iron, and overhead screens are placed at the working tables, to prevent the workers throwing stones to confederates outside the grounds. Notwithstanding all these precautions, a considerable loss by theft occurs.

The blue ground is brought to the surface in cars and is estimated by loads, which average 1600 pounds, four-fifths of a short ton. The yield averages about half a karat per load. For the fiscal year, closing about the middle of 1905, the De Beers Company reported:

Mined, 5,128,000 loads (a little over 4,000,000 short tons of blue ground; 2,210,314 karats obtained, a trifle over 1000 pounds. The karat is 3,168 grains. The money value was $24,000,000, so that the rough stone brings on an average $10.50 per karat. It is claimed by the managers that, in spite of their efforts, the loss by theft amounts to over one million dollars a year. The large proportionate yield of the De Beers Company gave it practical control of the diamond market, but as noted above, it now seems that all the other South African sources are syndicated in effect. The United States leads all nations in the importation of diamonds.

Diamond-cutting is a trade but a few centuries old. Amsterdam has long been one of its headquarters, and Jewish workmen most prominent in it. The cutting is much facilitated by the cleavage of the stone, by which, in skilful hands, the form may be

prepared in the rough, but the finishing is done by slow grinding. The standard form of the rough stone is the regular octohedron, often with rounded curved edges. Cubes are rare and are generally modified along the edges by several planes. Tetrahedrons, twinned and other modifications of the first system are found. Colors range from none to black through all the standard shades.

A well-formed octohedron may be cleft by a skilful workman through planes parallel to the base, so as to produce a comparatively broad, flat surface on one side of the base, and a narrow, flat surface on the other, then facets may be cut and a brilliant stone obtained. The cleavage is done by cutting a nick in the face of the stone and striking with a steel edge at the proper angle. The grinding is done by mounting the stone in a mass of fusible metal, which is fastened to a lever-arm so that the face to be ground rests on a plate rotating at high speed and bearing diamond dust. As each facet is finished, the stone must be reset in the fusible metal as to expose a new surface. Diamonds occasionally explode during these operations. This may be due to inclusions of liquid carbon dioxide. Dr. Joseph Leidy reported many years ago to the Academy of Natural Science, the explosion of a diamond in a ring which the wearer was holding in the sun. Diamonds are often in a condition of strain, hence severe treatment may produce structural changes. They are often heated strongly during cutting and sometimes develop cloudiness, which may or may not be removed by polishing. After this a second heating may not produce injury, as the strain has been removed. There is often great loss in cutting. The Koh-i-noor weighed 793 karats when brought to England. It was cut and lost 186.5 karats, and a second cutting lost 102 karats. The average loss is from one-half to three-quarters. Stones are occasionally of unequal hardness at different points. In cutting the Koh-i-noor one face was so hard that six hours' work with the wheel at 2400 r.p.m. produced no visible effect, and a much higher speed had to be used.

The largest diamond so far known was found at the Premier mine, in the Transvaal, in January, 1905. It weighs 3024.75 karats (9582.4 grains, very nearly one pound six ounces). It is an irregular prolate spheroid about four inches long. It is supposed to be a fragment of a much larger stone, but the other portions have not been found.

(Stated meeting held Wednesday, November 20, 1907.)

The Increased Gold Production and Its Effect Upon the Cost of Living.

By F. Lynwood Garrison,

Mining Engineer, Member of the Institute.

Within the past few months the question has been frequently raised, is not the enormous production of gold throughout the world responsible in some degree for the present extraordinary rise in prices of commodities, especially the necessities of life? This increase in the cost of living is apparently not confined to any one country, but is universal, at least in Europe and North America. The feeling seems to be pretty general that gold is being produced in such large quantities as to become cheap, in other words, the ratio between gold and food production has changed. It is possible to obtain approximately accurate figures relating to the gold element of the problem, but reliable statistics of the civilized world's food production do not seem to be available. We can safely assume, however, it is steadily increasing, and on the whole in perhaps no less degree than the growth of population. It will be necessary for us to further assume the ratio between the food supply and population a constant one, that is, one has not substantially gained upon the other during the past decade, although, of course, both have steadily increased.

Within the period from 1896 to 1900, the gold production of the world is given by the German statistician Soetbeer as \$1,286,505,000, and in the five years between 1901 and 1905 was \$1,611,155,000. Taking the individual years we find the yield in 1896 was \$202,251,600; in 1897, \$236,073,700, and in 1898, \$286,879,700, showing a ratio of increase of approximately 16¾ per cent. between 1896 and 1897, and 21 per cent. between 1897 and 1898. The world's production of 1904 was \$347,087,300,

and that for 1905 is officially given as $377,135,100* an increase of approximately 8½ per cent. The estimated production for 1906 is $400,000,000,† an increase of only 6 per cent. It would seem, therefore, that during the years of low prices and more or less business depression, the percentage of increase in gold production is nearly three times as large as in the years of great business expansion and high prices. This substantiates the dicta that within a period of public financial depression gold mining is one of the safest and most profitable occupations. It is evident from the above statistics that the actual increase during the years of low prices was much greater than in those of general prosperity. While obviously this does not show that the accumulation of gold has not affected prices, it does demonstrate that in years of depression the gold output is greatly accelerated. The question hence arises, has the amassing of gold been greater than the demands of increased business? It is difficult to see how it could, since the larger the volume of business the greater demand there must be for a circulating medium of exchange.

Some persons appear to erroneously consider that gold is an actual standard of value. It is of course in a sense an arbitrary one, the real standard being that of labor, the unit of which must be the amount of work a man can do in a given period, or, to use the words of Thoreau, "the cost of a thing is the amount of what I call life which is required to be exchanged for it." To support this life we must have food and when that increases in cost the price of labor must necessarily rise in like proportion.

Assuming that the general condition of trade throughout the world does not affect and is not influenced by the volume of gold production, the question arises, will the increase of the gold output keep pace with the demands for that precious metal, both for use as currency and consumption in the arts. Reviewing the production of gold in the United States in the year 1906, which was $94,373,800, we find that there has been a net increase over the year 1905 of $6,193,100, nearly all of which is credited to Alaska. The older gold-producing States of California, Montana, South Dakota, and Washington show a decreased production of approximately $300,000 each, and Colorado, Utah, and

*Report of Director of U. S. Mint for 1905, p. 37.

†Personal letter from Acting Director of U. S. Mint, October 22, 1907.

Idaho a small decrease, Arizona a slight increase and Alaska and Nevada an enormous advance. The great gain in production of the vast and virgin territory of Alaska was perhaps to be expected, but the increased production of Nevada from $5,359,100 in 1905 to $9,278,600 in 1906 was surprising, and is chiefly attributable to the remarkable discoveries of rich gold and silver ores in the Tonopah and Goldfield districts. It is doubtful, however, if this ratio of increase or even the same rate of production in Nevada can be maintained, since it is believed by well informed mining men that the yield of the Tonopah district has about reached its limit, as several of its best mines are showing signs of exhaustion. This is what might be expected from the injudicious manner in which some of these fine properties have been managed, or rather mismanaged.

In California hydraulic mining is not holding its own, and shows signs of dying out, whilst the dredging industry is increasing and has abundantly demonstrated its profitableness in favorable localities. In fact, it is safe to say that this form of gold washing and recovery is in its incipiency, and as it grows and develops, is certain to increase the gold production in many districts, thus materially assisting in maintaining a steady yield from the older producing areas. The quartz gold production in California has not substantially increased, but perhaps may do so as successful methods are developed for treating very lean ores. The writer cannot account for the falling off in the production of Colorado in 1906, as the labor troubles which so seriously affected the mining industry of that State appear to have been fairly well settled. It may be, that owing to the agitation produced by these disorders, capital has been scared away, and comparatively few new mining enterprises were inaugurated in Colorado. In Montana a large proportion of the gold production is from copper ores, and as this yield has steadily increased, the falling off in the gold output must be ascribed to other causes; in fact, since 1904 there has been a steady increase in copper and a marked decrease in gold production. In South Dakota the improvements and economies at the great Homestake mine seem to have failed to hold the gold production to a steady figure, since there has been a decrease of $110,700 between 1904 and 1905, and of $309,000 between 1905 and 1906. In Utah for 1906 over half of the $5,130,900 of gold output was from copper ores. In Idaho the gold

production is chiefly from placer mining, and showed a decrease between 1905 and 1906 of $39,900. Except in Alaska there has been a decided falling off of the yields from placer or gravel mining as far as the United States is concerned. This is what might be expected, for placer and gravel washing is always the first mining system adopted when a new gold producing territory is opened up. After such alluvial deposits are exhxausted, the miner seeks for "quartz" gold or ledges, generally with unsatisfactory results, for such men are usually inexperienced in milling as well as under-ground mining. On the whole, it would appear that with the exception of Alaska placer or alluvial gold mining in the United States as an industry is dying out, and is giving way to dredging. The increased production of gold seems to be largely due to the copper ores, and to the exceptionally rich though somewhat erratic gold and silver deposits of central and southern Nevada. In this State it is doubtful if the present rate of production can be maintained, unless new gold deposits are discovered, and the expected large production of copper ores in the Ely district yields abundantly of the precious metals. While of course it would be unsafe to assert that the present ratio of gold production in the United States proper (not including Alaska) cannot be maintained, it is nevertheless difficult to see where the gold is to come from. Of Alaska we have reason to expect great things, for this vast territory is but partly explored, even in a geographical sense, but doubtless it also has its limitations.

Turning now to other parts of the world, we find that the gold yield of the Transvaal has about reached its maximum, since the best authorities appear to agree that it will from now on steadily decrease. The yield of this justly celebrated district is enormous, and is now considerably over $100,000,000 per year. Other sections of South Africa are not very promising with the possible exception of Rhodesia, which in 1905 yielded $7,224,605. The gold production of Mexico is relatively not large, but there is reason to expect it will steadily increase. The same may be said of the Central American States and South America, which probably contain to-day the largest unexplored and undeveloped sections of the habitable earth.

In Europe, Russia is the only great gold producing country. The yield of European Russia and Siberia in 1904 being 37,321

kilos of gold, and in 1905, 33,541, equivalent to $22,251,587, the decrease in the year being ascribed to the disturbed political conditions of that country.

The conclusion is therefore unavoidable that the world's gold production has not reached an abnormal or unhealthy proportion when compared with the enormously increased commercial activities of the times. On the contrary, if anything, we need more gold, for business seems to have outgrown the supply of circulating medium, that is, coined money or currency. Gold is certainly not cheaper, and as some of the chief present sources of supply are exhibiting indubitable signs of exhaustion, it is not likely to become so. It is therefore evident that if the present rate of increase is to be maintained we must soon call upon the comparatively undeveloped fields of Siberia, Central and South America, and perhaps parts of Africa, although the prospects for gold in the latter country are not encouraging.

Continuing this analysis further, we find it is evident the quantity of gold derived from copper ores must be quite large. In the statistics for Arizona and California, this particular phase of the yield seems to be given only in terms of silver, that is, the amount of gold thus derived is not specifically stated. In Montana, however, $1,434,935 of the total $4,889,233 of gold produced by that State in 1905 came from the copper ores; that is, about 29 per cent. of the gold yield of the State was thus obtained, and in 1906 it was probably much larger. New Mexico, for 1905, gave $76,455, or about 29 per cent., from copper ores, whilst in Oregon it was only 1½ per cent. Within the old gold producing States it seems we will in the future have to look to the dredging industry and the copper ores for the increase of gold production, if, in fact, we are not obliged to depend upon these sources to maintain the present amount and prevent a steady decline. The total yield of gold as an incident of the copper industry is evidently an important element, although the precious metals thus derived are proportionately very small and may be regarded as a by-product, since copper ores do not usually contain more than one or two dollars of gold and silver per ton, the ratio being about one part of gold to three or four of silver. The yield of these metals from this source will therefore

depend upon the production of copper, which in turn is regulated by the price of that metal.

From a careful consideration of the whole subject, it is evident the gold production of the United States (not including Alaska) is not likely to continue exhibiting a substantial increase, if in fact it can maintain its present rate. There are doubtless many gold deposits of one kind or another in the United States that could be made to pay enormously in a country like China, where there is an abundance of cheap, and for the purpose, efficient labor, but in this country of high prices and extravagant living, such deposits would probably not yield a new dollar for an old one, even with the best of our so-called and sometimes over-rated labor-saving appliances. I believe it is an error to suppose modern mining and metallurgical methods can or will materially modify the gold production of the United States, although of course in some, and perhaps quite a number of instances, the yield of gold can in this way be increased, but as a factor of the whole question these modern innovations may be said to be comparatively unimportant.

Gold is not, as commonly supposed, a rare metal, indeed it is quite a common one in the crust of the earth, but it is exceedingly widely distributed and finely disseminated. It probably occurs in appreciable, though minute quantities throughout many, if not most of the Tertiary eruptive rocks that compose the vast chain of mountains extending from Alaska on the north to Tierra del Fuego on the south. The gravels underlying Philadelphia contain it, and the iridescent though dishonest scheme of Jernegan was based upon the substantial fact that gold does occur in sea water. The forces of Nature through millions of years have concentrated some of this gold in certain places favorable to its accumulation. By common process of erosion the particles of gold gather in stream beds, sea beaches and other alluvial and fluvial deposits. Through its solution in the circulating "waters under the earth" gold is carried from place to place in the rocks and precipitated in favorable locations, usually along with other metals. These latter phenomena are very obscure, but are slowly yielding to scientific study and research. In general, it may be said that the processes of metallic accumulation within the rocks are essentially superficial in the sense that they are probably going on at no great distance below the surface. Metallic veins and deposits do not usually increase in size or richness with great depth.

although there are of course some mines that can be worked about as far below the surface as our present mechanical limitations will admit.

In conclusion, it is difficult to see how the production of gold throughout the world can possibly continue to increase in the same rate as within the past few years, especially in the face of the continued increase in the price of labor, or to put it in another way, the cost of living. In the United States, especially in the manufacturing States like Pennsylvania, the land has been too frequently deserted by its tillers to labor in the factory, with a consequent increase in the cost of food and an absurdly high protective tariff has stimulated the manufacturing interests as alcohol will an individual, creating a brief sense of exhilaration followed by its distressing but inevitable reaction. Extravagance saps the wholesomeness of family life, and if continued is certain to destroy the nation.

GRANITE IN MAINE.

During the summer of 1905, Mr. T. Nelson Dale, of the United States Geological Survey, visited all the important granite quarries in Maine. The results of this work are soon to be presented in a bulletin entitled "The Granites of Maine," to which Dr. George Otis Smith has contributed an introductory chapter and map showing the geographic and general geologic relations of the granites in that State. The bulletin will also include the statistics of the granite production in Maine for 1905, prepared by Miss A. T. Coons.

The number of quarries and prospects visited, including those of "black granite" for monumental use, amounted to 129. The capital invested in the entire Maine granite industry in 1905 amounted to about $3,500,000. This estimate is based upon fair valuations of the quarries themselves, of the plants, and of the amount of "working capital" that is required to carry on the present business.

The report is designed to be helpful to those who are engaged in quarrying and working granite, as well as to architects, contractors, and dealers in monumental stone, and it will also make known to geologists the results of such scientific observations as were made in the course of the work. In order to accomplish these various purposes it has been divided into two parts—a scientific and an economic part.

The first is practically a brief text-book on granite in general, illustrated by the quarries of Maine and written as far as has been possible in untechnical, granite language, so as to be intelligible to working and business men. This part treats of the origin, mineralogical and chemical composition, texture, structure, physical properties, and classification of

granite and "black granites." Under the heading "Structure," the nature and origin of sheets, rift, grain, flow structure, joints, headings, and faults are considered. Dikes, veins, "knots," geodes, inclusions, and contracts are described and discussed, as well as the discoloration and decomposition of granite.

In the economic part the various tests of granite, the adaptation of the stone to different uses, and the methods of granite quarrying are first considered. An economic classification of Maine granites based upon visual characteristics is next given, and then follow the descriptions of the quarries and their products, the matter here being arranged by counties in alphabetic order. These descriptions follow a uniform method, taking up in succession (1) the name and location of quarry, name and address of operator and superintendent; (2) the granite, including its description in the rough and under the microscope, together with the results of any tests and analysis; (3) the quarry, its dimensions, drainage, and water supply; (4) the stripping and rock structure; (5) the plant, including an enumeration of all machines and pneumatic tools, to show its capacity; (6) the means of transportation; (7) labor, both of men and animals; (8) product, its uses and market, together with the names and location of buildings or monuments containing the stone.

At the end of the report is a bibliography on the economic geology of granite and a glossary of such scientific terms as were unavoidably used and also of current quarry terms. The report includes fourteen plates illustrating various features of scientific or economic interest in the quarries or their product and forty-one text figures. Most of these text figures are diagrams showing the course of joints, headings, and dikes at the quarries, but others illustrate "rift," sheet structure, "sap," or the use of explosives, or show the location of individual quarries at the industrial centers. The situation of these centers is indicated by symbols on the geological map.

WHY MONEY IS SCARCE.

Many theories are advanced as to the principal causes of the scarcity of funds that has existed for a long time, says the *Wall Street Summary*, A banker in this city, who has made a close study of the question, and who has been extremely conservative for many months, principally because of the monetary situation, says that he believes that a large amount of money is in the hands of laborers, artisans and others whose wages have been very materially increased within recent years. He believes that people of this class are carrying about a much larger amount of money than ever before. Others, who hold this same theory, point to the fact that the newly-arrived foreign element is receiving much higher wages than was ever paid to that class of people until a few years ago, and that many of them hardly know what a savings bank is, and consequently are simply hoarding their savings. It is believed that this situation is a very important factor in the money market.—*Iron Age.*

Section of Photography and Microscopy.

(Stated meeting held Thursday, November 7, 1907.)

A Color Screen Color Meter.*

By Frederick E. Ives.

The nearest approach to a universal color meter which is now commercially exploited for use in the arts and industries, employs arbitrary standards and scales, and different sets of standards for different arts, trades and industries. The numerical readings are of a complicated character, with an indefinite qualification of "brighter than standards" or "duller than standards," and the percentage values are quite unreliable because of the introduction of an indefinite number of reflecting surfaces.

By an adaptation of the fundamental principle of the Maxwell "color box," substituting a special photographic diffraction grating for the prisms in Maxwell's device, and making the instrument "direct vision" and compact, with slit adjustments controlled from a point near the eye, I made it possible without further complication to match, measure and record all such colors as can be found in the arts and industries. My diffraction color meter was demonstrated here on April 25th of this year, and the paper published in the *Journal* of the Institute in July.

I stated in my paper that some difficulty had been experienced in perfecting mechanism for giving accurate percentage readings of the opening of the three narrow and unequal slits. This was successfully accomplished, but there was reason to think that the correct adjustments might not always be maintained, and that users of the instruments might sometimes neglect to verify the adjustments before taking measurements. Although this, being a purely mechanical detail of the instrument, might very probably be satisfactorily perfected by a mechanical expert, it seemed to me to be worth while, before going any further with it, to see how nearly I could come to the same results by substituting three com-

*Read by title.

paratively large rectangular openings covered by special color screens for the slits and grating, and mixing the colors by an optical device, thus permitting of the use of much less delicate "slit" mechanism, and at the same time making it impossible to use wrong standards by shift in the spectrum.

I finally succeeded in obtaining practically the same results as with the diffraction color meter, without material alteration of size, general appearance, method of application or facility of adjustments, and with the further advantage that a much wider eye slit is used and the light is of exactly the same color at both edges of it.

Although this instrument differs very materially from its predecessor, it will be seen later that it represents a further evolution of the same idea. The two most novel elements in this device are, (1) a nearly juxtaposed set of three rectangular color screens which transmit respectively and exclusively the spectrum rays A to C 1/4 D (fundamentally pure red) a remarkably narrow and well defined band in the green with maximum at *b* (wave length 517) and from F 1/2 G to H (blue violet), and (2) a revolving wheel of convex lenses which optically mixes these colors to the eye, in the field of the instrument. For comparison purposes, a laterally placed clear aperture is provided, transmitting light which is bent into the axis over one half of the field by a wedge prism and spread across it by the optical mixing wheel in the same manner as the three colors.

It would have been impossible to produce a satisfactory device of this character but for the discovery, as the result of much experiment directed to that end, of means for producing a permanent green color screen transmitting very freely but exclusively the spectrum rays of a narrow band over *b* in the spectrum. The purest green glasses transmit a diffuse band of spectrum green very many times too wide, and therefore far too impure to compete with the narrow band taken from the spectrum in the Maxwell color box or the diffraction color meter. The green of this new screen is of such definite hue and purity that it serves the purpose practically as well as a sharp band taken out of the pure spectrum by prism or grating. It is also a permanent color screen, showing no trace of change after long exposure to summer sunlight, and the color is not changeable by adjustment, like the changes which would result from any accidental shift in a

spectroscopic device. Of course, the red and blue screens also possess these merits, but their production in my hands involved no extended experiment or special difficulty.

Maxwell measured the colors of the prismatic spectrum in terms of red at C, 1/4 D, the green at E, and the blue at F 1/2 G. Later authorities have generally chosen a green at *b*, or even a little further towards F, and in some cases a blue also nearer the F than Maxwell's. The green at E will not mix with the blue at F 1/2 G to absolutely match the spectrum at F, and the green at *b* will not mix with the red to absolutely match the spectrum at D. It is necessary, in both cases, to add a trace of white to the pure spectrum color in order to match it with the mixture. The green at *b* will give better average values throughout the spectrum than the green at E, and a blue nearer to G is necessary to match purples consisting of fundamentally pure red mixed with spectrum indigo-violet.

The colors which I have adopted have as nearly as possible the hue values of the spectrum at C, *b* and G, and that this triad is the best obtainable for a color meter to measure up all such colors as are to be met with in the arts and industries is absolutely proved by experiment on such colors.

A Maxwell color box, using Maxwell's primaries, failed on deep aniline violets which the screen color meter would match, and by reason of the yellower hue of Maxwell's green, it was no better for peacock blues than the screen meter; both would match all such peacock blues as are to be found in the arts and industries, with a difference only of percentage readings. Orange hues containing no trace of white cannot be exactly matched by mixing the *b* screen green with the red, but the purest of such colors in fabrics, etc., reflect enough white light superficially to make a perfect match possible.

By means of this color meter, every color to be found in the arts and industries can be quickly and accurately matched, measured in terms of three definite spectrum hues, recorded by three numbers, and reproduced for observation or matching at any time by simply setting the instrument to the recorded number and directing it to a background of standard white. It is not even necessary to introduce the letters R, G, B in the record, since if the numbers be given in the same order, the first is always to be taken as red, and the last as blue.

PHOSPHATE ROCK IN THE WEST.

The discovery of important phosphate deposits over a considerable area in southeastern Idaho, southwestern Wyoming, and northeastern Utah has opened up a new industry in the West. The future of the industry is, however, shrouded in uncertainty as it is largely dependent on the granting of such rates by the railroads as will enable the manufactured product or raw material to be sold at a profit in Australia, Honolulu, Japan, and the Middle States, the home market on the Pacific Coast not being at present extensive enough to warrant large development. This phase of the subject is recognized by Messrs. F. B. Weeks and W. F. Ferrier of the United States Geological Survey, who have investigated these deposits and prepared an article about them for the Survey's forthcoming annual volume. "Contributions to Economic Geology, 1906."

Prospecting has been carried on at a number of widely-separated localities. The strike of the beds follows the general northwest-southeast trend of the ranges along which they outcrop. In Idaho the beds outcrop along the Preuss Range, extending from the line of Bannock and Bear Lake counties in a southeasterly direction along its west face. A probable southern extension of these beds near the Idaho-Utah line is found on the plateau east of the Bear Lake, where the overlap of upper Mesozoic sediments has been eroded. East of the Preuss Range, in the Sublette Range, in Wyoming, are similar beds which follow the southerly trend of this range to Smiths Fork. The deposits are found in oolitic beds of the upper Carboniferous rocks and contain a variable percentage of P_2O_5.

This general region is drained by Bear River and its tributaries. The Oregon Short Line Railroad follows the valley of the Bear River and affords the only means of transportation to market. At present those beds which can be developed at the least cost and which lie nearer the railroad shipping points are worked. In Utah the phosphate series has been found some distance south of Bear Lake, in the vicinity of Woodruff. The beds also outcrop in Weber Canyon, about 1½ miles below Croydon, and in some of the side canyons. None of these beds are at present worked. The Union Pacific Railroad, which follows the course of Weber River, will make possible a rapid development in this region.

Beds of good grade, but too thin to be profitably worked, have been observed at other points in these States and also in Nevada. It is highly probable that further exploration will show that these oolitic phosphate beds have still wider distribution.

The phosphate series consists of alternating layers of black or brown phosphate material, shale, and hard blue or gray compact limestone. The limestones are in the main very fossiliferous. The phosphate series is in places about ninety feet thick. The beds vary in thickness from a few inches to about ten feet, but wherever they are of this extreme width they are broken by thin layers of shaly material poorer in P_2O_5. The main phosphate bed is from five to six feet thick, and is almost entirely oolitic in structure and high in P_2O_5. All the sections that have been examined show one, and some of them two beds which are of commercial value.

Mechanical and Engineering Section.

(Stated meeting held Thursday, October 31st, 1907.)

The Pitometer.

By Edward S. Cole.

Modern methods of economy have made their way into our conservative city water departments, and a desire to know what becomes of a costly water supply in its dark and hidden path from source to consumer has been aroused, so that a full accounting is now expected of the distribution engineer as well as of the official who collects the water rents.

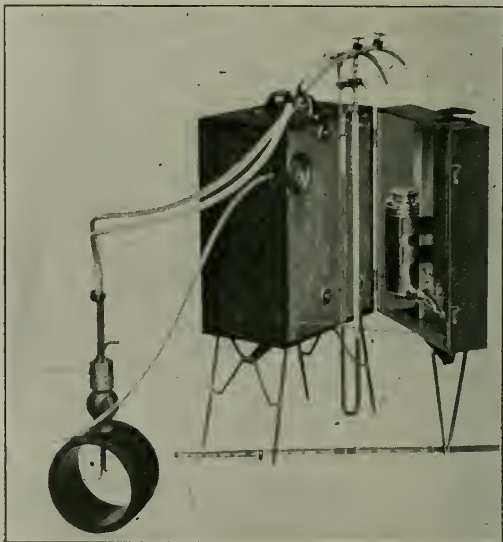
In attempting to account for his product the water works man has always been at a disadvantage because several feet of earth and costly paving cover the heavy iron pipes in which a water supply is distributed. To dig down and "cut in" one of the older types of meters is a very costly and difficult undertaking, so much so that important information has lain buried within these mains and much loss of revenue and of outlay has resulted.

Simple and portable means for recording the flow in pipes have been sorely needed to check the underground losses and waste which have grown to alarming proportions in nearly all American cities, and it has been because of this lack of means that our distribution systems, which are the most costly and vital part of a water works plant, consisting as they do of a vast gridiron of cast-iron mains, aggregating hundreds of miles and costing millions of dollars in any large city, have received less scientific attention than the more conspicuous features of a water works property. Thus while *filtration* has benefitted by the wonderful development of recent sanitary science, and a century of steam engineering has produced at last the high duty pumping engine,

but comparatively little has been done to improve the equally important pipe system by which water is distributed.

For the same cause costly extensions of mains have been left largely to guess-work, and much money thus thrown away for lack of the data on which their proper design depends.

Now, by use of the portable pitometer, measurements may be had at any point on such a system by simply making a tap and placing a one-inch service cock in the main, and such measurements may be repeated as often as desired at any time, by day or night, in winter or summer.



The Photo-Pitometer.

The development of the pitometer was taken up by the writer in 1895, under the direction of John A. Cole, C.E., in the hope of making use of the Pitot tube as a waste-meter at Terre Haute, Indiana, where an extensive examination of water consumption was being carried on. After much costly experimenting, suggested by a crude sketch contained in Prof. R. C. Carpenter's "Experimental Engineering," the instrument proved to be accurate and efficient, and since the addition of a photo-recorder, has been adopted on important tests in many of our largest cities.

Its fundamental principle was discovered by the French engineer, Pitot, about the year 1732, and later improved by D'Arcy for use in open channels, but the application to water-mains under pressure was developed only during recent years. The photo-record-

The "rod meter" and "street connection."

ing pitometer may now, however, be classed among our most useful and accurate engineering instruments.

Prior to 1895, when my work began, there seemed to be very little published data available to guide an investigator in this line.

It afterward appeared that both Mr. John R. Freeman, at Lawrence, Mass., and the late Henry Fladd, at St. Louis, had worked quite successfully toward a development of the Pitot tube in this direction. More recent contributions by Williams, Hubbel and Fenkel at Detroit; and Gregory and White, at Tulane University, have been made.

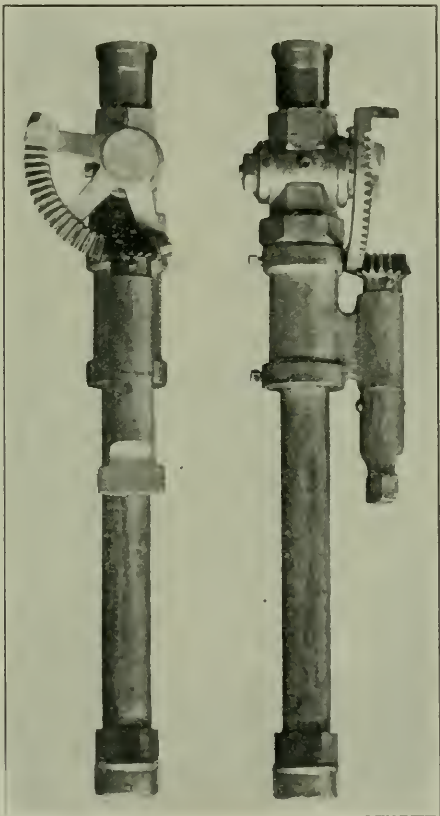
The pitometer is primarily a rate meter, depending as it does upon the velocity of the water within the main. It does not directly indicate the total discharge in cubic feet in a given time, as do ordinary meters, but this elimination of the time element proves to be valuable in a waste meter, for by the changes in rate we are able to study the effect of closing valves and service cocks in an investigation of underground systems.

The instrument consists of two small tubes bent at their lower ends, with carefully formed orifices, held in a suitable cap, which screws upon a standard 1″ corporation cock, through which the tubes may readily be introduced into any main and as easily withdrawn. The rod meter is the most recent development of the instrument by which the slender tubes are enclosed in an oval sheath which enables the meter to be introduced into the main from the surface of a city street through a "street connection" which is permanently set upon the main. Wherever street connections are placed they are always available for use, and through them by means of the portable rod meter the flow in the main can at any time be ascertained.

Heavy cloth insertion rubber tubing connects the orifice tubes with a long glass manometer, or U-tube, and blow-off cocks are provided to remove air from the instrument. The U-tube is half filled with a mixture of carbon tetrachloride and gasoline, having a specific gravity of 1.25, and when in use the water from the pipe fills all the remaining space in the U-tube and connections. The deflection, by virtue of the differential action of the water and the slightly heavier insoluble liquid, is just four times that due to the actual difference of water head on the orifices produced by the flowing stream. The current impinges directly on one orifice, but the other is turned down stream, and gives something less than the static head within the main, thus increasing the difference of pressure produced. This difference is then multiplied in the U-tube, the result being that even a low velocity within the pipe produces a readable deflection. Without this effect the simple

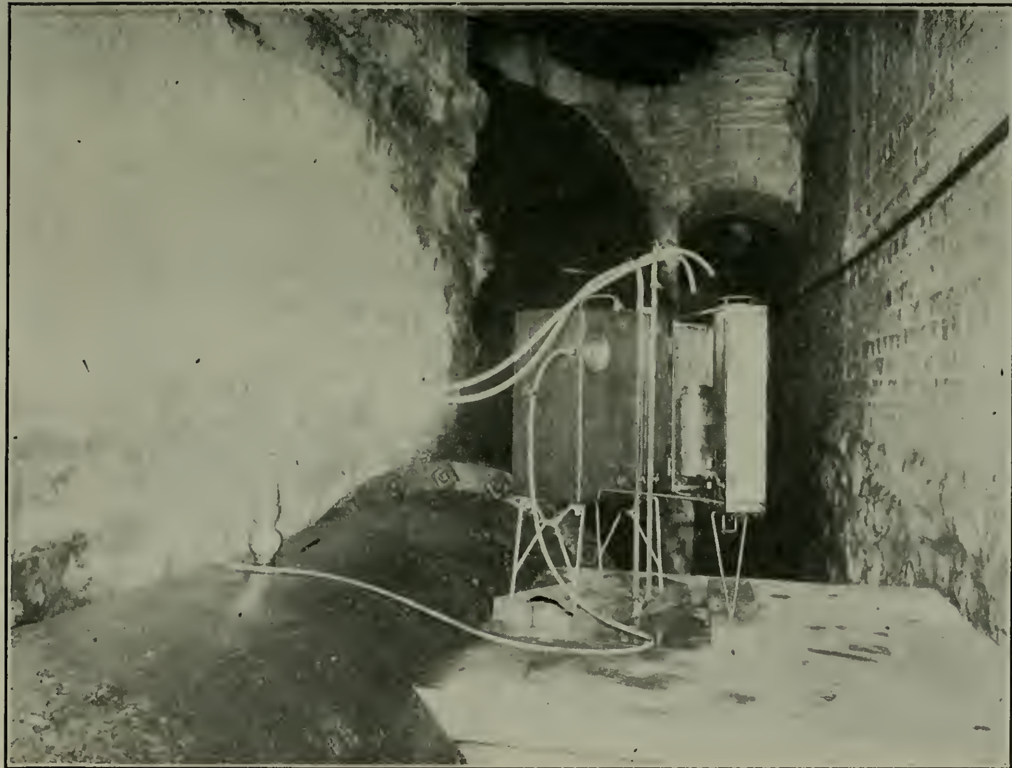
Pitot tube would hardly indicate a velocity less than one foot per second, while the pitometer is reliable at velocities as low as six inches per second. At ordinary velocities the U-tube deflections may run up to twenty-four inches, and therefore need not be read with any great nicety.

The photo-recorder consists of a portable box in which a drum



The "street connection."

carrying Velox or Azo paper revolves before a fine vertical slit just in front of which is locked one leg of the U-tube in such a position that the rays of light from an oil lamp will be partly intercepted on their way through the colored liquid in the lower half on the manometer. As the liquid rises and falls with the velocity in the pipe, it will record on the sensitized paper a line or



The pitometer at work upon a 16-inch main.

band of shade whose ordinates vary according to the well-known formula:

$$V = c\sqrt{2gh},$$

in which h is one-quarter of the U-tube deflection in feet, or half of the recorded ordinate on the paper. A twelve-hour photographic record is 18 inches long and 10 inches high. Autographic horizontal lines are formed by notches in the drum slit, spaced so as to correct for the angularity of the light and enable the true deflection to be readily taken from the diagram at any point.

An autographic record or variation in static pressure is superimposed upon the flow diagram by means of a suitably connected gauge and movable finger, which intercepts the light passing through the U-tube and slot. This pressure record is of great value in the interpretation of any sudden change in the rate of flow, for by its aid we may decide whether the observed variation is caused by a corresponding difference in pump pressure, as in "direct systems," or by the change in rate of draught within the district under investigation. Thus the detection of waste is facilitated.

The accuracy of the pitometer has been established by many weir tests, and also by calibration in open channels, where the absolute velocities indicated by the instrument are compared with float measurements.

The calibration constant c of the orifices has thus been experimentally determined to be .80 in our formula.

We have, then, $V = .8\sqrt{2\frac{gd}{4}} = 3.212\sqrt{d}$,

in which d is the U-tube deflection in feet. The actual velocity of the water is indicated in this way wherever the orifices may be placed within a pipe, and by completely "traversing" a given pipe section on two diameters, we may readily integrate the flow by the "ring method," compute the mean velocity, and find its ratio to the maximum at some one rate of flow.

This ratio once determined for a given pipe holds good at all velocities. The orifices are then permanently set to give the center or maximum velocity within the pipe, reading off the mean velocity and the discharge from a table prepared for the par-

ticular size of pipe and velocity ratio. This method leaves nothing uncertain. The mean velocity computed from a traverse of a pipe with the pitometer has been checked by careful weir measurement of the flow in pipes from four inches to seventy-two inches in diameter, indicating that with careful use the discharge in pipes may be determined by the pitometer within two or three per cent. of the truth, an accuracy which is highly satisfactory for the solution of practical hydraulic problems.

Such being the nature and form of the instrument itself, it remains to consider its practical utility and the several ways in which it has been applied to the problems which are presented by a modern water works plant in a rapidly growing city.

These naturally fall under two leading lines of investigation, each of which is of incalculable commercial importance, and in each of which the pitometer affords unique and economical methods. These are, first, the survey of underground pipe systems for the purpose of locating all uses and waste of water, incidentally ascertaining the condition of water mains, stop valves, and house services; and second, the supervision of pumps by means of which any loss of action or imperfection in work is revealed.

It is well to remember that water delivered under pressure through pipes is by no means a cheap product, and a few figures may help us to bear this in mind.

The actual cost of supplying one million gallons of water in many of our American works varies widely from about $20.00 in some of our large cities to $300.00 or more in the case of some small plants. The average for twenty-two cities of moderate size reported to the New England Water Works Association for 1904, was about $92.00 per million gallons for operating expenses and interest on bonds. In Chicago, where there is no filtration, the cost of water has been estimated at $19.00 per million gallons on the same basis. There, for example, the distribution system has two thousand miles of mains from four to forty-eight inches in diameter, valued at $16,000,000, or one half the cost of the whole Chicago water works system, which is placed at $32,000,000.

With the growing demand for pure water supplies, involving vast expenditures for filtration works, the cost of water is increasing. For example, the city of Philadelphia is completing filters to cost over $30,000,000, and the necessity of reducing waste here is obvious.

Waste of water is really *the* great evil in our American water works systems, and its effect upon city finances is twofold: First, in the desperate attempt to fill the "sieve," which our leaky systems resemble, large appropriations are needed year by year to increase the pumping capacity; and second, the pipe system needs continual re-enforcement to enable it to maintain adequate fire service over and above the useless losses which drain its capacity.

Broadly speaking, waste is not the generous, or even lavish use of water by consumers, but is rather the willful and careless misuse, by which streams run continually from faulty house fixtures and from leaky underground pipes. Water works losses include also the very serious problem of illegal *use* of water by large-meter consumers, through "by-passes," which rob the city of much needed revenue. Useless waste may amount to half the total supply of a city, or even more. For example, in his report on water measurements, Mr. Dexter Brackett, C.E., concludes that half the total supply of the Metropolitan District is wasted and obviously a waste of one-half is a serious matter.

In a water waste investigation a city is divided into large districts, closing all the main gates but one, placing a recording pitometer on the inlet to the district, and keeping a record of the inflow. This total use in connection with the district population and the amount registered by the private meters will give a good idea of the wastefulness of the section, taken as a whole, the rate of night use being most significant. In case the district shows a reasonable rate it may be passed by, thereby saving the expense and trouble of house to house inspection.

If, on the other hand, an excessive consumption per capita is indicated, the next step is to analyze the supply by streets, using the pitometer to record the "drop" in flow as valves are closed one after another. All streets do not waste water at the same rate per tap, and for this reason it is easier to pick out an unusual flow. When the night waste has been localized within a few blocks this smaller section is enclosed by itself and supplied through its own waste meter.

Then, if necessary, the curb cocks are closed one after another at night, the waste meter at the same time continuously recording the rate of flow, so that when a house is reached which has a leaky service pipe or fixture the pitometer on the main, on closing the main cock, will record a "drop," which is the rate of waste.

In this way a record showing the condition of every house on the street is obtained and waste is located, which can further be defined by house to house inspections. The waste meter record not only locates the loss on certain premises, but measures it.

This American method by the use of the pitometer is the development of the long-established Deacon system, which, although still very much depended upon in England, has not proved popular in this country, although for several years it was used in Boston with success.

Every large city should organize its own permanent department

A portable "shelter box" in use at Fairmount Park, Philadelphia.

ment of the systematic detection of waste according to some such plan as has been outlined, and in Washington, D. C., Pittsburg, and Chicago this has been done.

The work calls for the intelligent and skilful supervision of an engineer, and must be persistently followed up for years if need be, to secure the final results. The time required to traverse a square mile depends on the number of waste meters employed, and upon the physical condition of the pipe system. Several districts may be inspected at one time under the direction of one

competent head. Experience has amply proved the value of such work for its results are felt at once, and the cost may be repaid out of savings as the investigation proceeds.

The increase of income and the saving of expenditure for new pumps and mains will net millions of dollars to taxpayers. Purification works which will sooner or later be demanded in many of our leading cities, can be built from funds so saved without becoming a burden. *Waste prevention* and *water purification* are now the order of the day, and they ought to go hand in hand.

In New York City a recent report by Mr. James H. Fuertes, C.E., places the waste and unaccounted for loss at 43% of the total supply. In Chicago the probable waste is estimated at over 50% of the pumpage, and costly extensions will be needed continually for tunnels and pumping plants alone if the present wasteful conditions go on, whereas, if means are taken to control these losses, this great outlay may be avoided, and a still greater saving made in extensions to the distribution system; for this doubling of the consumption through waste increases the loss of pressure by friction threefold. The great cost of re-enforcing Chicago's $16,000,000 pipe system does not need to be enlarged upon, but it illustrates the importance of effective waste restriction in our cities.

When in our search for waste we analyze the daily consumption of cities or of districts we meet the difficult question as to what is a fair and reasonable supply, but, strictly speaking, there can be no such thing as a standard per capita consumption by which cities my be compared one with another. Much of the controversy regarding an adequate water supply arises from lack of knowledge of special requirements. For instance, it is folly to compare statistics of total per capita consumption without first separating trade and public uses from ordinary domestic demands. Then again the population per mile of main, the amount of lawn sprinklng per capita, and, above all, the relative luxury and personal habits of the several classes constituting the population of a city must be considered.

As an illustration, the city of Buffalo, with a total use per capita of over three hundred gallons, has a metered consumption for trade purposes alone of forty-six gallons per capita, more than the entire supply of Fall River. Evidently such statistics should

not be compared when cities may differ so widely in the trade use of water.

There is, however, ample opportunity for a study of definite and carefully classified uses, such as that made for the Metropolitan Water District (Boston) by Mr. Dexter Brackett, C.E., in which he found by actual measurement:

Domestic use	25.0	gallons per capita daily.
Manufacturing and trade use	23.5	" " " "
Public use	7.0	" " " "
Total	55.5	" " " "

or less than sixty gallons daily for each man, woman and child. Whereas the Metropolitan District actually received about 122 gallons per capita daily.

In other cities we have a reported total consumption per capita ranging from that in

Buffalo	over 300
Pittsburg and Philadelphia	over 200
New York, Chicago, St. Louis and Boston	from 130 to 160
Providence, Worcester, Fall River and Milwaukee	40 to 80

Abroad one finds such cities as London, Liverpool, Manchester, Glasgow, etc., reporting from thirty to sixty gallons. But there we find a policy of waste restriction has been highly developed.

In this wide range of supply to American cities the reported figures are liable to be in error from an unsuspected slippage in the pumps. One of the first discoveries to the credit of the pitometer was in a city of about 125,000 population, which had been reporting 33% more water than was actually leaving the pumps, and since that illuminating experience, pitometer tests show that leaky pumps are the rule rather than the exception, with losses from 25% to 50% by no means unheard of even in engines of the highest type and largest size. For example tests made last year in Philadelphia for Major Cassius E. Gillette, then Chief Engineer of the Filtration Bureau, revealed an average loss from all the pumps of about 25%, which should of course be deducted from the per capita consumption as ordinarily reported for that city.

A wide variation in per capita consumption is due, as has been

shown, to trade use, which will vary as cities are more or less devoted to manufacture.

Public uses, while but a comparatively small part of the total consumption, include the supply to public buildings, schools and hospitals. Street sprinkling, sewer flushing, and fire extinguishing call for attention when reducing the supply to a per capita standard.

Domestic consumption varies, as already stated, according to the habits of the people, and upon this point we are able to form a fairly well-based opinion as to what constitutes a reasonable allowance. For example, in Worcester, Mass., the total domestic use per capita, as shown by meter, is only 16.8 gallons, varying from twelve gallons in the cheaper houses to twenty-three gallons in the best residence streets.

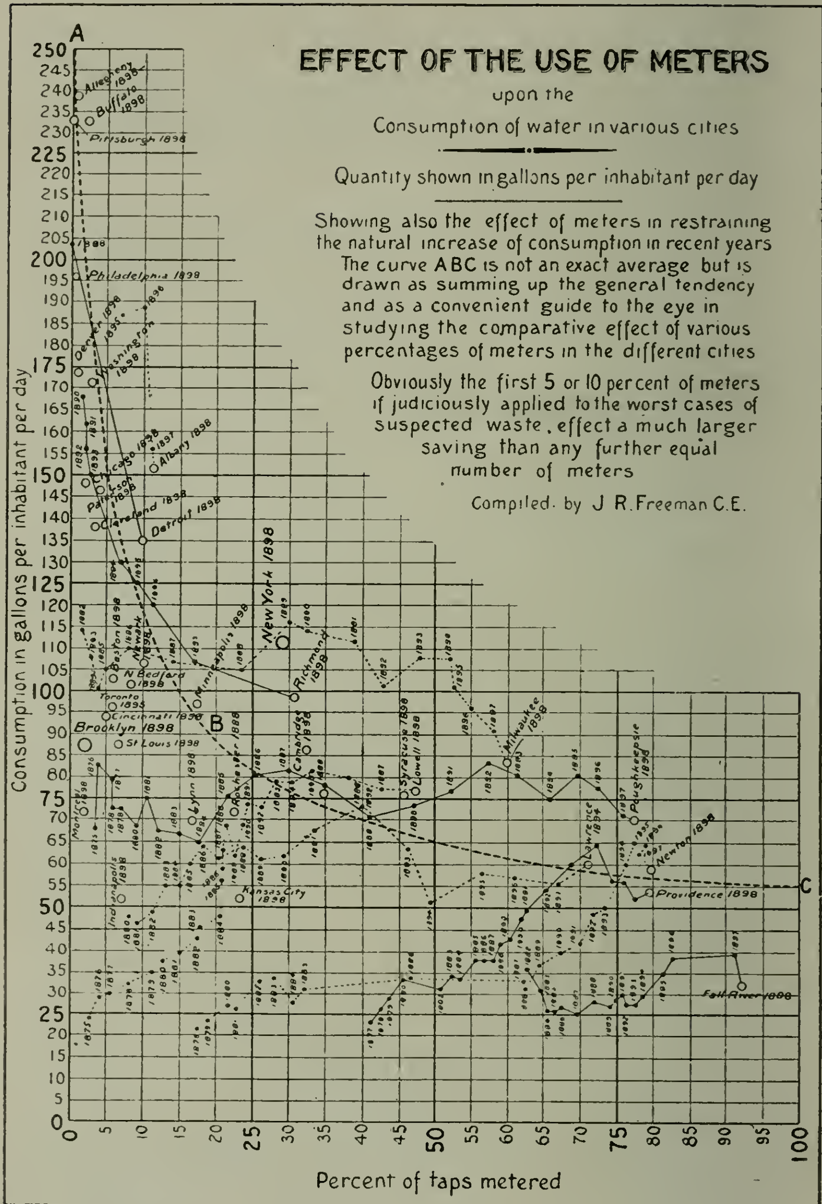
We should remember that such figures are for actual house requirements by meter measurements, and take no account of waste in the service pipe beyond the meter or in the street mains.

An examination of the hourly records of pumpage in cities is convincing as to the existence of waste. The notable feature of such records is that the rate is usually high, even at the dead of night.

While we cannot judge of the relative wastefulness in various cities by a comparison of the per capita consumption, we find in reviewing statistics that the use of meters is attended with a reduction of waste. An interesting diagram first prepared by Mr. John R. Freeman, gives the use per capita of many cities and the percentage of taps metered in each. No better argument for the judicious use of meters should be needed. The effect of placing meters on about 40% of the consumers, including the largest, seems to indicate that a further addition of meters does not yield a proportionate saving. Evidently losses beyond the reach of house meters come in at about this point, and point to the need of special waste investigation. The introduction of a meter system should, therefore, be supplemented by tests for restricting losses in street mains and services.

Leaks beyond the reach of the house meter are undoubtedly larger than supposed, as evidenced by recent tests and meter comparisons.

In a number of cities having practically every tap metered, there is a discrepancy of from 30% to 50% between the total


EFFECT OF THE USE OF METERS
upon the
Consumption of water in various cities
Quantity shown in gallons per inhabitant per day
Showing also the effect of meters in restraining the natural increase of consumption in recent years
The curve ABC is not an exact average but is drawn as summing up the general tendency and as a convenient guide to the eye in studying the comparative effect of various percentages of meters in the different cities
Obviously the first 5 or 10 percent of meters if judiciously applied to the worst cases of suspected waste, effect a much larger saving than any further equal number of meters
Compiled by J R. Freeman C.E.
Consumption in gallons per inhabitant per day
Percent of taps metered
A
B
C
Allegheny 1898
Buffalo 1898
Pittsburgh 1898
Philadelphia 1898
Denver 1898
Washington 1898
Chicago 1898
Albany 1898
Paterson 1898
Cleveland 1898
Detroit 1898
Boston 1898
Newark 1898
N Bedford 1898
Toronto 1893
Cincinnati 1898
Brooklyn 1898
St Louis 1898
Minneapolis 1898
New York 1898
Richmond 1898
Cambridge 1898
Rochester 1888
Lynn 1898
Montreal 1898
Indianapolis 1898
Kansas City 1898
Syracuse 1898
Lowell 1898
Milwaukee 1898
Lawrence 1894
Poughkeepsie 1898
Newton 1898
Providence 1898
Fall River 1898

pumpage and the total meter registration. This unmistakable loss often remains after allowing for unmetered public uses, fires, and for slip pumps. Leaky, broken, and abandoned service pipes are responsible for much waste, which, because of a porous soil, may not give warning at the surface.

Electrolysis has often been the cause of deterioration of city mains and services and should be carefully studied.

All of the reported pumpage does not reach the main because of what is known as "slip," and "station use" at the pumps. It is customary to make only very small correction for this loss and, in fact, the statistics of most cities are based upon the full amount of water displaced by the pump plungers, the almost universal method being to multiply the recorded strokes of each engine by the theoretical number of gallons displaced per stroke. The only merit of this method lies in its simplicity. That it is liable to gross error has been found on many occasions when the actual discharge from a pump has been measured and compared with the counter record.

This loss should always be determined and deducted from the reported supply to a city, for evidently slip at the pumps is not only misleading, but requires the same engine capacity, steam, and fuel as though the full plunger displacement were discharged into the mains.

DISCUSSION.

Professor Easby.—Please explain more fully how you insure accuracy by your method of gauging the flow in a pipe.

Mr. Cole.—In the first place, the absolute velocity at the orifices as indicated by the corresponding U-tube deflection has been carefully calibrated in a long open trough by means of loaded floats made to run over a measured course. These floats were timed by electrical contact made automatically at each end of the measured course and recorded by chronograph. In our experiments the trough was of wrought-iron, in the form of an open semi-circular conduit forty feet in length. The measured course was laid out some distance below the head of the trough at a point where the depth of flow seemed to be uniform. The whole affair was hung from a supporting I-beam so as to be adjustable to various slopes. Our pitometers were introduced through 1″

taps placed vertically beneath the trough, the orifices rising to within $\frac{1}{2}''$ of the water surface.

A direct comparison between velocity as determined by the floats and chronograph was thus made with the corresponding U-tube deflection and the plotting of a large number of such comparison tests gave us a calibration curve which when compared with the theoretical flow gave us the value of c equal to .80 in our formula :—

$$V = c\sqrt{2gh}.$$

Thus when gauging the flow in a pipe, we are able to plot the actual velocity at various points in the cross-section by "traversing" two diameters inch by inch from side to side. The orifices ought to remain at each point long enough to give several readings of velocity, the mean of which is plotted so that on completing the traverse we have a curve representing the distribution of velocity from side to side in the pipe. Where, as is often the case, the rate of flow is not uniform, it is necessary to return frequently to the center of the pipe to guard against error through a change of rate. It is often convenient to use two instruments, allowing one to remain at the center, while the other is moved from point to point across the pipe. Observations are of course only taken when the center velocity is normal.

The next step is to divide the cross section of the pipe into a series of rings and approximately equal area, multiplying the area of each by the average velocity for that ring as given at four points ninety degrees apart by the two traverse curves. The summation of discharges found for these rings is, of course, the total flow in the pipe, which divided by the whole area of the pipe gives the mean velocity and this in turn when divided by the maximum velocity observed at or near the center of the pipe determines what we call the "pipe coefficient," which commonly varies according to the condition and age of the pipe from .70 to .90. This ratio of mean to center velocity is the characteristic of each pipe location where a gauging is sought and must first be carefully obtained. When once determined, however, it holds good at all velocities at that particular location, and it is only necessary to leave the pitometer orifices at the point of maximum velocity in order to record the mean flow, which, for practical purposes, will always be a fixed percentage of the maximum. A scale is prepared for each pipe based upon

the computed coefficient. By means of this scale the rate of discharge in million gallons per twenty-four hours for each inch or fraction of an inch of U-tube deflection may be read off from the record.

The final test of the accuracy of a pitometer gauging rests upon the comparison of flow as determined by the above method with that given by a standard weir or measuring tank. A number of tests have been made with weir comparisons in pipes of several sizes up to 72″, and notably at the laboratory of the Worcester Polytechnic Institute, where a very perfect weir receives the flow of a 30″ pipe. We feel justified by our experience in claiming an accuracy of from two to three per cent. in fairly clean pipes when the pitometer is carefully handled.

(Question asked by the Chairman, Mr. Day):

What is the effect of tuberculation upon a pitometer gauging?

Mr. Cole.—No attempt is made to accurately measure the flow by our method in a main which is found to be badly corroded. However, the very process of traversing the main as described will reveal the presence of tuberculation, for its effect is to abnormally diminish the velocity near the side of the pipe and thereby reduce the velocity ratio. The net area may often be obtained by the introduction of a caliper which enters the main in the same manner as the pitometer itself and by touching the top and bottom of the pipe will give a fair idea of the net diameter at that point. It is usually quite easy to find a suitable point for gauging the flow to any given district through a pipe comparatively free from corrosion. Ample warning is given by the result of the preliminary traverse, so that an error due to tuberculation is unnecessary. In much district work, especially where flow is obtained by differences between the indications of two instruments, accuracy in the determination of absolute flow is of less importance, as relative values or changes in flow are sought.

Mr. Bambery, Assistant Engineer of the Gas Improvement Co.—Why is it that one of the pitometer orifices is turned down stream instead of the common form of static pressure?

Mr. Cole.—Among many forms of orifice tried these were adopted early in our experimental work because they gave much more reliable indications than the older form. Moreover, the U-tube deflection corresponding to a given velocity was thereby somewhat increased, allowing us to produce a measurable deflection for a velocity somewhat less than ½ foot per second.

MICA DEPOSITS OF WESTERN NORTH CAROLINA.

Although classed as one of the lesser minerals, mica is of considerable importance in the commercial world. Its chief value is in connection with the electrical industry, but it is also used in the manufacture of stoves, lighting apparatus, wall paper, lubricants, paints, boiler covering, fire-proof apparatus, etc. About half of the mica consumed in the United States is of home production; the other half is imported, chiefly from India, though a small amount of "amber" mica comes from Canada. The States contributing the home production in 1905 were, in order of relative rank, North Carolina, Colorado, New Hampshire, Georgia, South Dakota and New Mexico, over two-fifths of the whole being credited to North Carolina.

The mica deposits of western North Carolina have been examined by several investigators working for the State Geological Survey, and with the permission of the State Geologist, a brief paper on the subject, prepared by Mr. Douglas B. Sterrett, appears in Bulletin No. 315 of the United States Geological Survey, "Contributions to Economic Geology, 1906." A detailed report will be published later by the State organization.

Active mica mining has been carried on in North Carolina for the last thirty-eight years, though with varying degrees of energy and success; and the remains of ancient workings, with crude stone tools, around some of the better deposits, suggest early mining by the aborigines or prehistoric people. It is claimed that the earliest mica mining in the State was done in Jackson County on prospects known to Mr. Davis. After a number of Mr. Person had seen a specimen of mica from this county exhibited at the State Fair at Columbus, S. C., by D. D. Davis; and nine years later, when the value of mica was more fully recognized, Mr. Person started operations in Jackson County on prospects known to Mr. Davis. After a number of years' depression, due to low market values at a time when India mica was imported into the country in large quantities, the production is again increased, and old and new mines and prospects are at present interesting many companies and private concerns.

Mr. Sterrett's paper discusses briefly the occurrence, distribution, and origin of the mica-bearing rocks and the minerals associated with the mica, and describes the principal mining properties. Persons who are interested in the subject may obtain a copy of the bulletin by applying to the Director, United States Geological Survey, Washington, D. C.

A NEW METAL called Hydeslite is being produced at a new works, the Hydeslite Metal Company, 2065-2069 Arizona street, Philadelphia. It consists of an amalgamation of various minerals, and when mixed with brass it imparts to it extraordinary strength. While common brass will crumble when exposed to great heat, experiments show that when mixed with hydeslite it will bend or roll hot, neither breaking nor crumbling. Philadelphia manufacturers of goods requiring brass finish are taking so kindly to the new metal that the company is arranging to enlarge greatly the capacity of its plant.—*Iron Age.*

ELECTRICAL SECTION.

(Stated meeting held Thursday, October 10, 1907.)

The Electro-Thermic Production of Iron and Steel.

By Joseph W. Richards, Ph.D.

Professor of Metallurgy in Lehigh University; Professor of Electro-chemistry in the Franklin Institute; Secretary of the American Electrochemical Society.

Why is the metallurgist becoming so largely an electrometallurgist? Because as scientists and industrial men are learning better how to handle electric currents, how best and most efficiently to utilize their decomposing and heating power, they find at their command agencies which can perform what were formerly technical impossibilities, apparatus which can produce at commercially possible costs products hitherto mere chemical curiosities or even ranking among the "chemical unknowns." The mechanical engineer has aided this art by his skill in utilizing water powers, in perfecting gas engines, and in inventing high-efficiency boilers and steam engines. The electrical engineer has contributed still more, by his design and construction of gigantic dynamos, the transmission of large powers to great distances, the conceiving and perfecting of large electrical furnaces. The metallurgist and chemist have utilized these labors of their colleagues to devise new schemes for the extraction of the metals from their ores, new ways of melting metals, new methods of refining metals, new processes for converting cheap raw materials into valuable products of different composition, and finally altogether new products made by novel reactions and adaptable to entirely new and original purposes. There is no need here to specify, in order to prove the proposition; the latest books and the most recent

journals are full of the surprising achievements of the electrometallurgist and the electrochemist.

In the scientific development of every art, there are always three stages: First, the experimenter, who thinks, imagines, devises, speculates, wonders if this thing will work, wonders if that reaction is possible, and then finally, on a small scale, determines that some reaction or transformation or decomposition of some kind is a possibility which was never proved so to anyone's satisfaction before. This much being gained, the second stage is entered: is the thing capable of being worked on a large scale? This requires the devising of large and often entirely novel apparatus, the overcoming of unforeseen difficulties, the consideration of many new factors. Frequently the apparatus or process finally evolved on a large scale bear little or no resemblance to the original laboratory experiment. Here the metallurgist must plan, calculate, design, and often invent as many novel features as he has difficulties to overcome. The process once working on an industrial scale, the final test of whether it will survive or not will be its ability to command a market for its product, its strength to stand fierce competition from the older processes now fighting for their existence, the capability of the manager to notch down expenses, notch up efficiency, and ever to improve on the quality of the product and its regularity of production.

We may now look at the avenues by which electricity has approached the commercial metallurgy of iron.

Burgess,* of the University of Wisconsin, has shown in his laboratory how iron may be electrolytically refined by a process similar in most of its details to the electro-refining of copper,—until it is turned out practically chemically pure iron, except for a trace of hydrogen, which later is driven off by heating to redness. Here is an electrochemical method of refining worked out to this point: Pure iron, purer than ever before commercially made, can undoubtedly be furnished in any quantity desired at a cost of probably $10 per ton above that of the mild steel used. The Carnegie Institution very generously and very wisely defrayed the cost of these experiments, by a grant of $2500, and it is altogether probable that the exacting demands for pure material by makers of high-class steels of special and very exact composition,

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*Transactions of the American Electrochemical Society, Vol. v, 1904.

will lead in the near future to the establishment of a commercial refinery operating Burgess's process, for the production of the highest class of pure commercial iron ever at the command of steel makers. If a rapid tool steel sells at 50 to 75 cents per pound, what is one-half cent per pound on the cost of the raw material if it gives a material to start with which is absolutely pure and therefore of invariable composition?

But the above is not the "electro-thermic" production of iron or steel, and we must back to our subject.

Iron and steel are made, universally, by thermal methods, and the electro-thermic production of these products means simply their production by thermal processes in which the energy of the electric current *as a heating agent* is more or less, or altogether, depended upon to work the process. Pig-iron is made by reducing iron ore by carbon in blast-furnaces; it can also be made by reducing iron ore by carbon in electric furnaces. Steel is made by melting together wrought-iron and cast-iron in a crucible or on the hearth of a Siemens-Martin furnace; the same constituents can be melted together to equally good steel in an induction, arc or resistance electric furnace. Steel is also made by causing iron ore to react on pig-iron, in the open-hearth furnace; the same reaction can be carried out in several types of electric furnaces. Again, iron or steel can be refined in the melted state by oxidizing in the presence of a proper liquid slag; ordinary refining furnaces are limited in the nature of the slag they can use by the limited temperature at their command; electric furnaces can push the refining to much greater limits because of the higher temperature at their command permitting working with highly effective slags ordinarily considered infusible and unuseable. Finally, iron and steel are melted in cupolas, reverberatory furnaces, open-hearth furnaces and crucibles, in order to make castings; they can be melted to liquid material usually of better quality by the use of electric melting furnaces.

I have said that these things *can* be done, meaning by that that they are possible; whether they are commercially possible depends on a dozen of other conditions, which we will duly consider.

The electro-thermic metallurgy of iron has to do with two different problems:

I. The electro-thermic production of Steel.

II. The electro-thermic reduction of Iron Ores.

Speaking chronologically, iron ores were reduced first to wrought-iron, and from wrought-iron steel was made by cementation in red-hot carbon. Afterwards iron ore was reduced in blast-furnaces to pig-iron, which was either used itself in the arts, or served as the basis of production of wrought-iron by the puddling processes, or steel in the crucible.

SIEMENS' EXPERIMENTS.

The development of the electro-thermic production of steel dates from the experiments of Siemens, in 1880, who attempted to use a combined arc-resistance furnace for melting down steel. In this case the material to be melted, held in a plumbago crucible, formed one pole and a water-cooled copper conductor the other pole. The arc between the two furnished the chief resistance and source of heat energy. The material to be melted, by its broken structure, poor contacts between the pieces and with the crucible, formed the smaller part of the resistance. With 1.6 horse-power, 500 grams of steel was melted in fifteen minutes; with 13 horse-power, 2700 grams of wrought-iron in twenty minutes. Since a kilogram of melted steel contains at least 300 calories, and a melted wrought-iron 350 calories, the heat imparted by the current was—

1.6 H.P., 15 minutes $= 300 \times 0.5 = 150$ Calories.
13 H.P., 20 minutes $= 350 \times 2.7 = 945$ Calories.

Since one H.P. hour $= 642$ Calories, the full equivalent of the power used in the two cases was—

1.6 H.P., 15 minutes $= 642 \times 0.4 = 257$ Calories
Thermal efficiency $= \frac{150}{257} = 0.584 = 58.4\ \%$.
13 H.P., 20 minutes $= 642 \times 4.3 = 2761$ Calories
Thermal efficiency $= \frac{945}{2761} = 0.342 = 34.2\ \%$.

While these efficiencies do not appear at first sight high, yet when they are compared with the efficiencies of 3 to 5 per cent. of the heating power of the fuel put into the steel while melting it by coke in a crucible set in a melting-hole, the difference is striking.

The commercial question at once arises: Why was Siemen's method not profitable on a large scale? The answer is to be found in the imperfection of the furnace and not in its inefficiency. The water-cooled copper electrode was dangerous, for it quickly

wore through. The means of regulating the current was not very good, causing great fluctuations in the current passing. The crucible itself became highly heated by the current passing through its walls and lasted but a short time. The steel absorbed both carbon and silicon from the crucible, and copper from the other electrode, and was thus changed in composition. The whole operation and apparatus was conceived on too small a scale. The efficiency, however, so far as the operation went and while it lasted was not bad; power expended at the rate of 585 kilowatt-hours per metric ton of steel melted, while 350 are theoretically necessary.

THE INDUCTION FURNACE.

This was the first to be commercially successful in producing steel. The furnace is a transformer with a secondary of one turn, which latter is a groove filled with the material to be melted. The lining of the furnace—the sides of the groove—were first made of silica, but later of magnesia; the latter was most durable. The induced current generates heat by overcoming the resistance alone of the material to be melted. There is no arc, no electrodes, no movable crucible. The furnace may be placed on trunnions so that it can be poured.

There is only one determination published of the resistivity of molten iron; it is stated by Gin to be 0.0002 Ohm per centimeter cube. The resistance of a circular or other shaped closed groove containing melted iron can therefore be calculated roughly. In an induction furnace the amperes in the secondary of one turn will be those in the primary circuit multiplied by the number of turns, less losses due to magnetic leakage. The energy generated in the iron will be as its resistance multiplied by the square of the amperes passing:

$$Q = RA^2 = \frac{r\,l}{s}A^2.$$

but the weight of iron is:

$$W = \frac{l\,s}{g}.$$

Therefore heating effects per unit of weight of iron

$$\frac{Q}{W} = \frac{g \times A^2}{S^2}$$

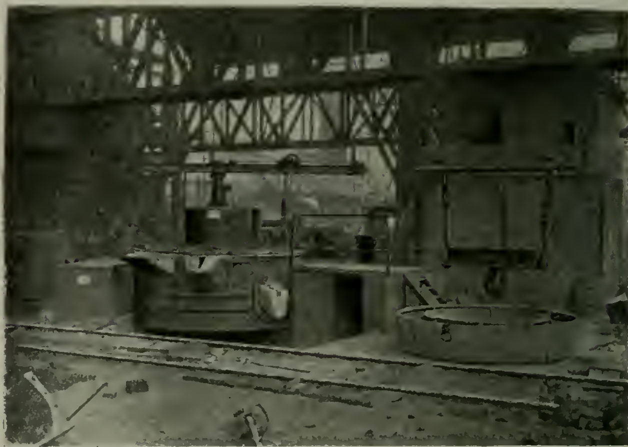

Fig. 1 The 1000 H.P. induction furnace at Voelklingen.

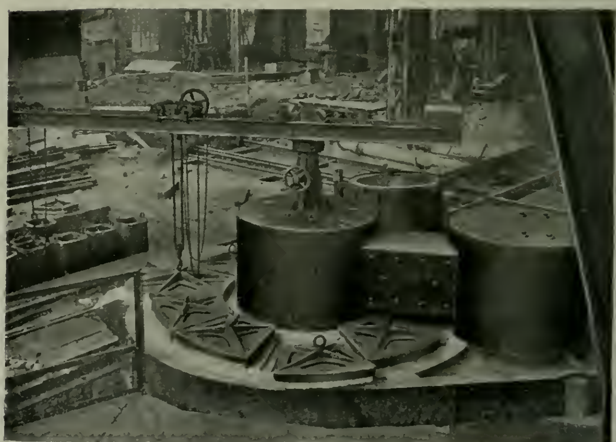

Fig. 2. Top view of same, showing covered groove containing the melted metal.

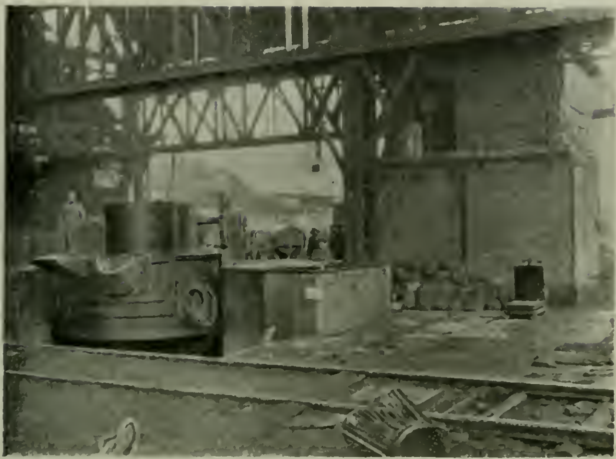

Fig. 3. View of same during construction.

Fig. 4. Back view, showing tilting mechanism.

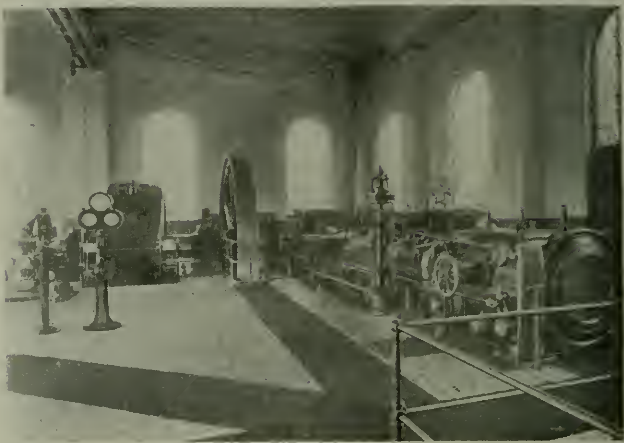

Fig. 5. Power house, showing gas engine.

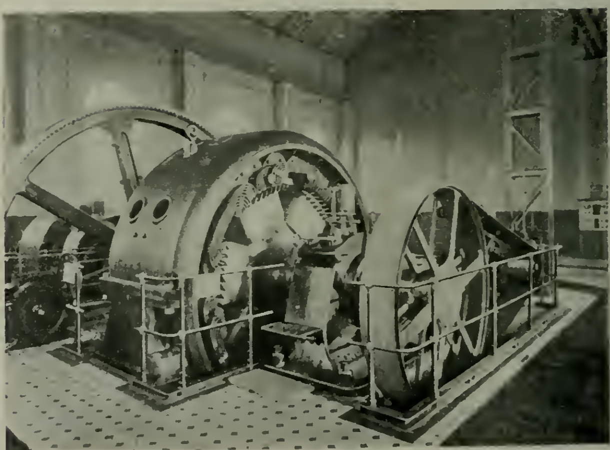

Fig. 6. Alternating current dynamos used.

From this we see that the rate at which energy is delivered to each unit weight of iron varies, for one thing, inversely as the square of the cross-section of the metal in the groove.

The Kjellin furnace first installed at Gysinge, Sweden, in February, 1900, held only 80 kilograms of steel, and with a 78 kw.

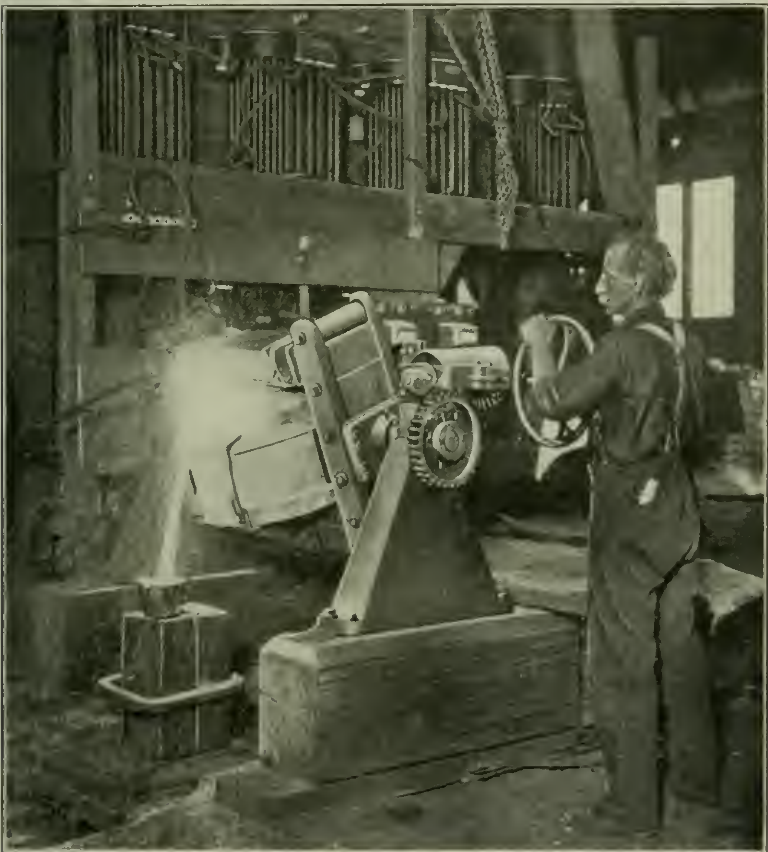

Fig. 7. The Disston furnace.

dynamo produced 270 kg. of steel in twenty-four hours. In November, 1900, a furnace holding 180 kg. was built, and with 58 kw. of electric energy made 600 to 700 kg. of steel per day. Next a furnace holding 1800 kg. of steel was built, run by a 300 H.P. turbine directly driving a dynamo giving 3000 volts on the primary windings of the furnace. This furnace is still in opera-

tion, making 5000 kg. of steel per day. Another furnace has been built and is now running, operated by 165 kw. of current, holding 1350 kg. of steel, and turning out from pig-iron and scrap, charged cold, five tons of steel per day, and when using melted pig-iron six tons.

The American Electric Furnace Co., which builds the Colby and Kjellin electric furnaces in this country, is now supplying steel melters with induction furnaces varying from 25 lbs. of steel capacity, requiring 10 kw., up to 18,500 lbs. capacity, requiring 736 kw. (1000 H.P.). The latter furnace melts 80,000 lbs. of steel in twenty-four hours, with an expenditure of 600 kilowatt-hours per ton of steel if charges are put in cold, and 500 kilowatt-hours per ton with melted pig-iron forming one-third of the charge. A furnace on the same principle to melt charges of 150 tons is now in course of construction at the Roechling Iron Works, Voelklingen, Germany.

Taking the above figures, it will be seen that the induction furnace is attaining a high degree of thermal and metallurgical efficiency. The waste during melting in the induction furnace is only 2.5 per cent., whereas it is some 5 per cent. in open-hearth practice.

PROBLEM I.

Taking the data given above for the output of Kjellin furnaces of increasing sizes, calculate for each the net thermal efficiency.

Solution: One kilogram of melted steel, sufficiently overheated to allow of casting, will contain at least 275 Calories if high carbon steel and 325 Calories if low carbon steel; say 300 Calories for average steel. One kilowatt-hour furnishes 860 large Calories, as its heat equivalent. We have then the following calculations for the furnaces in the order given:

270 kg. melted in 24 hours by 78 kw.

$$\text{Efficiency} = \frac{270 \times 300}{78 \times 24 \times 860} = 0.051 = 5.1\ \%.$$

700 kg. melted in 24 hours by 58 kw.

$$\text{Efficiency} = \frac{700 \times 300}{58 \times 24 \times 860} = 0.18 = 18\ \%.$$

5000 kg. melted in 24 hours by 300 H.P. at the turbine = 224 kw. = 200 kw. effective electrical power at the furnace.

$$\text{Efficiency} = \frac{5000 \times 300}{200 \times 24 \times 860} = 0.36 = 36\%.$$

5000 kg. melted in 24 hours by 165 kw.

$$\text{Efficiency} = \frac{5000 \times 300}{165 \times 24 \times 860} = 0.43 = 43\%.$$

80,000 lbs. (36,400 kg.) melted per day by 736 kw.

$$\text{Efficiency} = \frac{36{,}400 \times 300}{736 \times 24 \times 860} = 0.72 = 72\%.$$

96,000 lbs. (43,600 kg.) melted per day by 736 kw., if one-third is put in as melted pig-iron, carrying 250 Cal. per kilogram.

$$\text{Efficiency} = \frac{(43{,}600 \times 300) - (14{,}500 \times 250)}{736 \times 24 \times 860} = 0.62 = 62\%.$$

Charging part of the charge melted is seen to lower the net thermal efficiency, but to increase the output of the furnace. With cheap power, the latter item is of the greatest importance.

LITERATURE ON THE INDUCTION FURNACE.

Zeitschrift für Elektrochemie, *8*, 710 (1902); *9*, 517, 658 (1903).

Elektrochemische Zeitschrift, *10*, 122 (1903).

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Stahl und Eisen, XXV, Feb. 1, 15; March 1, 1905; XXIX, Jan. 9, 16, 1907.

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Germany: 126,606 (1900).

HÉROULT'S FURNACE.

The Héroult tilting electric furnace resembles a tilting open-hearth furnace, with two large electrodes passing through the center of the roof. The electrodes are built up of carbon slabs.

170 centimeters long and 36 centimeters square, at a cost of about twenty cents per kilogram. The hearth is stamped in burnt dolomite, the roof silica brick; the electrodes are protected inside the furnace by water jackets, to prevent their combustion by the air. The furnace can hold 4000 kg. of steel, costs $10,000, and such a one has been in constant operation in La Praz, France, since 1903. The electrodes dip only into the slag, so as not to be dissolved by or carbonize the bath. The current used is 110 volts by 4000 amperes, alternating, and the principal resistance and seat of generation of heat is in the slag between the ends of the carbons and the metal. A disadvantage of this furnace is that it cannot operate without a considerable layer of slag being present.

In such a furnace steel can be made in a variety of ways. Mr.

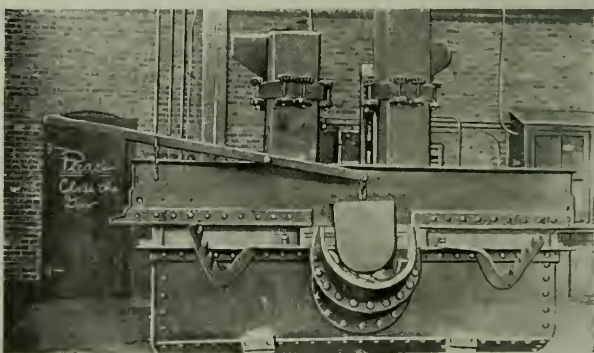

Fig. 8. Front view of a Heroult furnace.

Héroult has preferred to make it from the cheapest raw materials, by processes similar to ordinary open-hearth practice. As is well known, this involves the use of pig-iron, scrap iron or steel and iron ore. The only difference between the two processes is that in the open-hearth furnace there may be considerable oxidation by the gases in the furnace, but in the electric furnace iron-ore must be relied on as the oxidizing agent; it is therefore used to a larger extent than can be used in the open-hearth practice. Considerable lime is added to help form a fusible and basic slag. The oxidation of the impurities consumes time, and therefore the amount of electrical energy required per ton of steel is greater than in the cases cited in the Kjellin induction furnace, where

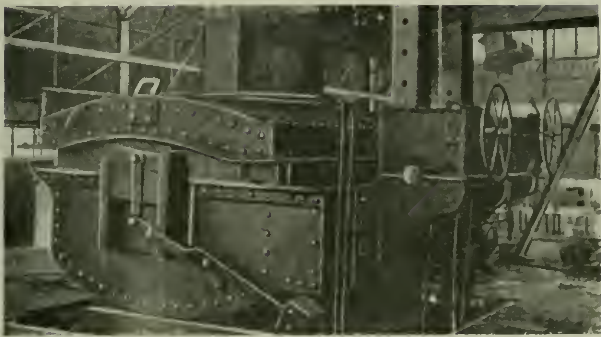

Fig. 9. Back view of same.

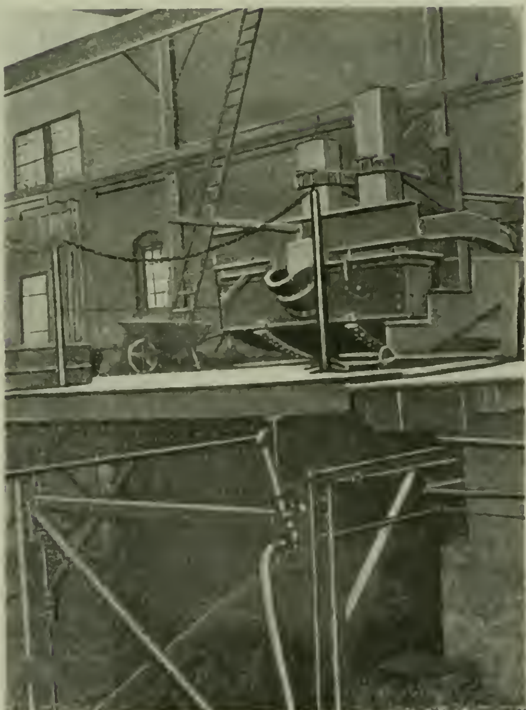

Fig. 10. Showing mounting of a Heroult furnace and casting pit.

high-grade pig-iron and clean scrap were simply melted together in proper proportions.

PROBLEM 2.

A charge composed of—

Miscellaneous steel scrap	5,733 lbs.
Iron ore	430 "
Lime	346 "

was placed in a Héroult furnace, and in five hours twenty minutes was completely melted to soft steel, yielding 5161 lbs. During the melting 1,680 kilowatt-hours of electric energy were used.

Required:—The thermal efficiency of the furnace.

Solution:—The steel scrap is 572 lbs. heavier than the soft steel produced, or 10 per cent. It is very evident that the iron ore used (probably 90% Fe^2O^3) oxidized some of the carbon, manganese, etc., of the scrap, and that the scrap itself was probably oxidized. Miscellaneous scrap may easily be rusted so far as to lose 5 per cent. of its weight while melting down. Calling the soft steel practically pure iron, and the loss of the scrap to represent iron oxide going into the slag, we have as the net result of the melting 5161 lbs. of pure iron and a slag containing silica iron oxide and lime, weighing approximately:

Ferrous oxide	860 lbs.
Silica	43 "
Lime	346 "
	1249

Heat in melted soft steel

$$5161 \times 340 = 1,754,740 \text{ lb. Cal.}$$

Heat in slag

$$1249 \times 550 = 686,950 \text{ " "}$$

$$2,441,690 \text{ " "}$$
$$= 1,109,850 \text{ kg. "}$$

Heat value of current used

$$1680 \times 860 = 1,444,800 \text{ " "}$$

$$\text{Efficiency} = \frac{1,109,850}{1,444,800} = 0.77 = 77\%.$$

In working this furnace, with these materials, the slag produced is a necessary part of the operation, and the heat it contains may be taken as usefully applied heat.

These furnaces lend themselves very well to use in connection with melting pig-iron from cupolas or blast furnaces, or melted steel from the Bessemer converter or open-hearth furnace. The electric furnace is fitted to take hot metal, the product of the ordinary steel furnace, and by reason of the higher temperature available to make a slag which will entirely de-phosphorize the metal.

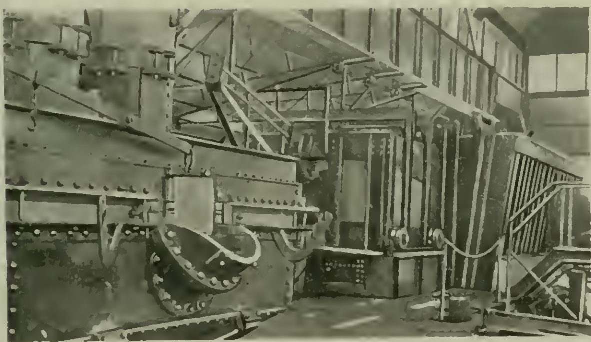

Fig 11. Showing Heroult furnace alongside an open hearth furnace, and worked in conjunction therewith.

Such working leaves on the other furnaces the calorific burden of melting the charges and giving them to the electric furnace fully liquid, leaving to the latter merely the task of raising the temperature a little higher and smelting upon them a very basic slag. In such cases, steel corresponding in quality to crucible steel is obtained at but a small cost per ton advance upon that of the Siemens or Bessemer steel from which it is made. The electrically imparted heat is here mostly used to supply radiation losses, and only a minor fraction to increase the temperature of the steel. We cannot, therefore, in justice to the furnace, calculate its thermal efficiency in the manner applied to the case of melting a charge down. In fact, in such cases we can only compare different furnaces on the basis of weight of metal *kept* melted per given time, *e. g.*, per ton of metal kept melted one hour.

ELECTRO-THERMAL REDUCTION.

The most interesting application of electric furnace methods to the metallurgy of iron is in the line of producing cast-iron, pure iron or steel direct from iron-ore. To this may be added the production of ferro-alloys, either by the reduction of other metallic oxides in the presence of iron or mixed with iron ore.

THE FERRO-ALLOY INDUSTRY.

This field has already attained commercial importance in the ferro-alloy line, such as in the manufacture of ferro-manganese, -silicon, -chromium, -tungsten, -vanadium, -boron, -titanium, etc., and a large and steadily increasing industry has been built up. There are probably a dozen electrical ferro-alloy works now in operation, and the industry is flourishing.

The *raison d' être* of this industryis as follows: In the blast furnace, metallic oxides more difficult to reduce than iron oxide are decomposed to varying and often to only trifling degrees. The blast-furnace will easily reduce 99 per cent. of all the iron oxide put into it, losing only 1 per cent. of it in the slag, unreduced. Manganese oxide is not so completely reduced; perhaps 50 to 75 per cent. of it is reduced to manganese and alloys with the iron, forming a product as high as 85 per cent. manganese, while the slag contains the rest, as unreduced Mn.O. Since good manganese ores are scarce and expensive, this loss is annoying and costly. Silica is always present in the blast furnace, and up to 25 per cent. of it may be reduced to silicon, forming a 10 or even 15 per cent. silicon pig, but there the blast furnace reaches its limit; the temperature is not high enough to produce a richer silicon alloy. A low per cent. chromium alloy may be made in a blast furnace, but a great waste of chromium in the slag; a high per cent. chromium alloy cannot thus be made. Tungsten oxides can be reduced to ferro-tungsten in crucibles, but only to a low per cent. tungsten alloy and with much unreduced tungsten in the slag. Titanium, vanadium, boron cannot be reduced to any appreciable extent by carbon and non-electric heating. In all these cases cited, alloys much richer in the non-ferrous metal, and much more complete reduction of the material used, can be obtained in the electric furnace.

Just as electrically-made steel has first found a footing as a competitor of the most expensive kind of steel—crucible steel—so electrical reduction has first found footing in the metallurgy of iron in the production of the most expensive and difficult ferro-alloys.

As an example of the calculations attaching to this branch of the subject, and of methods applicable to all the ferro-alloys, I would cite the production of ferro-silicon, which is attaining constantly increasing commercial and industrial importance.

(*To be concluded.*)

Book Notices.

NEW PUBLICATIONS.

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Michigan State Board of Health. Thirty-third Annual Report of the Secretary for the fiscal year ending June 30, 1905. 214 pages, 8-vo. Lansing, State Printer, 1906.

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A new study of nature by George W. Edgett, B.L. 30 pages, portrait, 12-mo. No place of publication, no date.

From Rime to Reason, or the great San Francisco earthquake rhythmically, orchestically and logically considered. Clarence Miller Jones. 25 pages, 8-vo. Second edition, revised. Columbus, Ohio. Printed for private distribution only, August, 1907.

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Lidgerwood-Miller Marine Cableway for Coaling in the Seaway. 48 pages, illustrations, 4-to. New York, Lidgerwood Manufacturing Co., 1907. (Copies sent free on application.)

Pond Rigid Turret Lathe. 43 pages, illustrations, 12-mo. New York, Niles-Bement-Pond Company, 1907.

Deuxiéme Étude sur l'appareil Circumzénithal par Fr. Nusl et Josef Jan Fric. 42 pages, illustrations, plate, 4-to. Reprint from Bulletin de l'Academie des Sciences de Bohême, 1906. Prague, Academy, 1906.

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Fourth Annual Report of the Superintendent of the Bureau of Government Laboratories for the year ending August 31, 1905, to the Honorable, the Secretary of the Interior, by Paul C. Freer, Superintendent of Government Laboratories. 24 pages, 8-vo. Manila, Bureau of Printing, 1906.

Zevy's Engineers' Contract Book (blanks intended for the use of engineers), folio sheets. Canton, Ohio. The Goheen Manufacturing Co. n. d.

U. S. Department of the Interior, Geological Survey. Mineral Resources of the United States, calendar year 1905. David T. Day, Chief of Division of Mining and Mineral Resources. 1403 pages, 8-vo., cloth. Washington, Government Printing Office, 1906.

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Issue and Redemption of National Bank Guaranteed Credit Notes. Report from the Committee on Banking and Currency, submitted by Mr. Fowler. To accompany House Report No. 23017, 59th Congress, 2d session, December 20, 1906. 29 pages, 8-vo. n. p. n. d.

U. S. Commerce and Labor Department, Coast and Geodetic Survey. Appendix 3. Report for 1906. Terrestrial Magnetism. Results of Magnetic Observations made by the Coast and Geodetic Survey between July 1, 1905, and June 30, 1906, by L. A. Bauer, Inspector of Magnetic Work. Pages 107 to 209. 4-to. Washington, Government, 1906.

Appendix No. 4. Report for 1906. Terrestrial Magnetism. Distribution of the magnetic Declination in the United States for January 1, 1905, with Isogonic chart and Secular Change Tables, by L. A. Bauer. Pages 213 to 226, maps, 4-to. Washington, Government, 1906.

U. S. Navy Department, Bureau of Steam Engineering. Annual Report for 1906. 41 pages, 8-vo. Washington, Government, 1906.

Sections.

(Abstract of Proceedings.)

Section of Physics and Chemistry.—The Section held a stated meeting on Thursday evening, October 24th, at 8 o'clock, Dr. Edward Goldsmith in the chair. The paper of the evening was presented by Mr. F. P.

Veitch, of the U. S. Department of Agriculture. His subject was: "Wood Turpentine: its Manufacture and Commercial Uses."

Mr. Veitch spoke of the rapid growth of this new industry in the United States, more especially in the Southern and Northwestern States, described the various processes of manufacture, and referred at length to its use in the arts as a substitute for turpentine spirit made from gum resin. The speaker illustrated his remarks by the exhibition of numerous specimens of the produ t, varnishes made therefrom, and a number of panels of wood varnished with wood turpentine varnish.

The subject was freel discussed and the speaker was voted the thanks of the meeting. Adjourned.

Wm. H. Wahl, *Sec'y pro tem.*

Mechanical and Engineering Section.—A stated meeting of the Section was held on Thursday evening, October 31st, at 8 o'clock. Present, fourteen members. President Charles Day in the chair.

The Chairman introduced Mr. Edward S. Cole, of New York, who read the paper of the evening on "The Pitometer," an instrument specially adapted for measuring and locating the leakage of water in water mains, from imperfections in pumps, and other sources of waste in the water supply of cities.

The paper was fully illustrated with the aid of lantern pictures. The discussion which followed was participated in by Mr. J. C. Trautwine, Jr., Major Cassius E. Gillette, late Chief of the Bureau of Filtration in Philadelphia, Prof. Easby, of the University of Pennsylvania, Mr. Bamberg, representing the United Gas Improvement Company, the Chairman and others. The speaker was given a vote of thanks, and his paper was referred to the Committee on Publication. Adjourned.

Francis Head, *Secretary.*

Section of Photography and Microscopy.—The forty-third general meeting of the Section was held on Thursday, November 7th, at 8 o'clock P.M.

Present, forty-three members and visitors. Dr. Henry Leffmann, President, in the chair.

Mr. Edward T. Wherry, B.S., presented a paper on "Radio-Active Minerals in Pennsylvania," in which he gave an account of his experiments with a number of minerals found principally in Southeastern Pennsylvania, for the purpose of determining the presence or absence of radio-activity in them. These minerals belonged chiefly to the uranium group, and many were found in the neighborhood of Philadelphia. The speaker described his method of operation, stating that he had secured the best results by the use of X-ray plates and an exposure of from three to ten days.

Specimens of these minerals were shown, and the evidence of their radio-active properties was presented in the form of lantern photographs.

The paper was freely discussed and was referred for publication The speaker received a vote of thanks. Adjourned.

M. I. WILBERT, *Secretary.*

MINING AND METALLURGICAL SECTION.—A stated meeting of the Section was held on Thursday evening, November 14th, at 8 o'clock.

Present, thirty-two members. Mr. G. H. Clamer, President, in the chair.

The subject of the paper for the evening was "Recent Advances in the Metallurgy of Zinc," and was presented by Mr. Woolsey McA. Johnson, Metallurgical Engineer, of New York.

The communication was discussed by Mr. C. J. Reed, Mr. Carl Hering, Dr. Edward Goldsmith, and the Chairman. A vote of thanks was passed to the speaker. Adjourned.

WM. H. WAHL, *Sec'y pro tem.*

SECTION OF PHYSICS AND CHEMISTRY.—The Section held a stated meeting on Thursday evening, November 21st, at 8 o'clock. Present, twenty-three members and visitors. Dr. Edward Goldsmith in the chair.

Dr. Allerton S. Cushman, of the U. S. Department of Agriculture, read a communication on "The Corrosion of Iron and Steel," illustrated by numerous experiments and diagrams.

Referred, after some discussion, for publication.

The speaker received a vote of thanks, and the meeting was adjourned.

WM. H. WAHL, *Sec'y pro tem.*

The Franklin Institute

(Proceedings of the stated meeting held Wednesday, November 20th, 1097.)

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, November 20th, 1907.

PRESIDENT WALTON CLARK in the chair.

Present, forty-two members.

The President, on behalf of the Committee on New Building, made a brief statement of the results of the work of the Committee in soliciting subscriptions to this fund. He reported that over two hundred thousand dollars had been pledged by friends of the Institute, which assured the grant of the Franklin Fund to the Institute. The Committee was hopeful, he concluded, that the fund available for the future requirements of the

Institute would be increased by at least one hundred thousand dollars more before the first of April next.

The first communication of the evening was presented by Prof. F. L. Garrison, on "The Production of Gold, and Its Effects on the Cost of Living."

Mr. Strickland L. Kneass followed with an account of some tests made by the late Prof. R. H. Thurston, on "The Wire Cables of the Old Suspension Bridge over the Schuylkill River."

Mr. Romeyn B. Hough, of Lowville, N. Y., who was represented by Mr. Chas. E. Ronaldson, made a communication on "The Characteristics of American Woods," illustrated by a large number of admirable thin sections of typical indigenous woods.

The last subject was referred to the Committee on Science and the Arts.

Prof. Garrison, duly seconded, made some complimentary remarks referring to the zealous and prolonged efforts of Prof. Lewis M. Haupt, in behalf of the establishment of a connected system of internal waterways along the Atlantic Coast, and moved that the Institute reaffirm its previous action in commending this important project. Carried.

Adjourned.

WM. H. WAHL, *Secretary.*

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